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FINAL REPORT

SPACE SHUTTLE ORBITER

DIGITAL DATA PROCESSING SYSTEM

TIMING SENSITIVITY ANALYSIS

OFT ASCENT PHASE

18 FEBRUARY 1977

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SYSTEM DEVELOPMENT CORPORATION
2500 COLORADO AVENUE ▫ SANTA MONICA, CALIF. 90406

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J. J. Lagas, Project Head
J. J. Peterka
D. A. Becker

Approved by R. W. Bilek

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ABSTRACT

This Final Report provides the results of a 7-month study by System Development Corporation (SDC) that involved the simulation and analysis of the Space Shuttle Orbiter Digital Data Processing System (DDPS) This dynamic loading analysis was performed for the NASA Johnson Space Center under contract NAS9-15010 Segments of the Ascent Test (OFT) configuration were modeled utilizing the Information Management System Interpretive Model (IMSIM) in a computerized simulation modeling of the OFT hardware and software workload.

System requirements for simulation of the OFT configuration were defined, and sensitivity analyses determined areas of potential data flow problems in DDPS operation Based on the defined system requirements and these sensitivity analyses, a test design was developed for adapting, parameterizing, and executing IMSIM, using varying load and stress conditions for model execution Analyses of the computer simulation runs are documented herein, including results, conclusions, and recommendations for DDPS improvements

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1 SUMMARY

This report summarizes the results of a simulation analysis of the Space Shuttle Orbiter Digital Data Processing System This study was performed for the Systems Analysis Branch of the Avionics Systems Engineering Division of NASA's Johnson Space Center. The study was conducted by members of the Systems Analysis Center, Systems and Space Programs, of System Development Corporation under contract NAS9-15010, and was performed during the period of 19 July 1976 through 18 February 1977.

NASA Technical Monitor has been Mr Carroll T. Dawson of the Systems Analysis Branch Under Mr. Dawson's direction, SDC has performed an extensive simulation modeling analysis utilizing the IMSIM simulator Total emphasis has been on the ascent phase aspects of the orbiter's Digital Data Processing System (DDPS) SDC personnel involved in this study and primary responsibilities were

Richard W Bilek - Head, Systems Analysis Center overall project supervision and quality assurance
Jacobus J Lagas - Project Manager: requirements definition, test design, execution, and analysis.
James J Peterka - model adaptation, execution, and analysis
Dennis A Becker - requirements definition, sensitivity analysis, and model parameterization.

1 1 OBJECTIVES

As the end product of this contract, this report constitutes an analysis of the ascent portion (OPS 1) of the Orbital Flight Test configuration of the Space Shuttle's DDPS, and identifies constituents of the system which are potentially subject to overload under stress and which may significantly degrade performance of the system in a critical situation The analysis is based on a quantitative representation of the DDPS as a discrete simulation model and on the results derived from the operation of this model. This report also includes a qualitative study of the system organization and structure to determine the adaptability of the system to varying loads and requirements This information was used to parameterize the model and was instrumental in completing the analyses

1 2 DATA SOURCES

Sources for the study included current documentation of the DDPS OFT functional subsystem software requirements documents (FSSRs) and detailed design specifications as listed in appendix F Upon NASA direction, the study was primarily confined to the hardware and software which may be employed during the ascent phase of the Orbital Flight Test (OFT). These efforts were applied to investigation of characteristics and activities which are discernible to a time resolution of 1 millisecond; i.e., items such as control signals, IOP memory access for commands, parity checking, and CPU instruction execution were considered only insofar as collective effects are concerned. The effort was

focused on quantitative data processing aspects of DDPS; i.e., data flow, throughput, response, etc., rather than upon planned information content or quality, reliability, human engineering, or other more qualitative aspects.

Level A Hardware specifications for Approach and Landing Test (ALT) and the FSSR System Interface documents for ALT were used in part to determine the DDPS OFT hardware configuration and the nature of the components to be connected to the GPCs via data buses for communication and control These documents, employed earlier by SDC to develop the simulated hardware configuration depicted in reference 4, were used in conjunction with additional detailed information contained in supplementary hardware specifications (see references 12, 15, and 21) to determine the simulated hardware configuration for OFT These sources also provided information on the processing rates of the Central Processing Units (CPUs), capacities for data retention by terminal elements such as displays, transmission rates for components and data buses, and sizing of message transmissions. Documents pertaining to the CPUs and Input-Output Processor (IOP) functional descriptions and principles of operation were consulted to gain an understanding of the functioning of these modules.

Level C Software FSSRs for OFT Guidance, Navigation, and Control (GN&C) plus computer program development specifications for OFT were used to determine the structure of the DDPS software Significant program modules (viz. the Principal Functions that execute during the Ascent Phase) to be executed in these simulations were also determined from these documents For each of these program modules, characteristics were determined with regard to the conditions for executing the module, the impact of system status on the execution time of the module, the effect that execution of the module has on the system status, and the data transmissions performed by the module This information was used to compile a set of system states and to estimate program execution times for the DDPS which were principal factors in determining system loading

1 3 MODEL DEVELOPMENT

The information which was derived from study of the source documents as described in section 1 2 was used to adapt and parameterize a discrete event simulation model of the DDPS The basic model is a computer program simulator for information management simulation, denoted as "IMSIM" (Information Management System Interpretive Model) This program was originally developed by SDC under contract to NASA to provide methods and capabilities for performing dynamic loading studies of computer-based data processing systems, and has been well suited to the simulation of the Shuttle Orbiter DDPS IMSIM is described in detail in the IMSIM Users Manual (reference 2), and is summarized in section 5.1.3.

Hardware characteristics of each component of the DDPS were transcribed to IMSIM input specification forms, and configuration specification forms were used to specify the connection of terminal elements and memory units to data buses The DDPS components so represented were the Display Electronic Units, Display Units, Multiplexer/Demultiplexers, Display Driver Units, Keyboard Units, PCMMUs, Engine Interface Units, Master Event Controllers, and the Memory Units and CPUs of the GPCs The data buses themselves were represented as IMSIM "datalinks" in the model (see appendix B for a detailed listing of IMSIM input specifications)

Depiction of the software for simulation is somewhat more complex than the hardware representation. It is necessary to exercise value judgement in deciding whether a program module is to be individually represented, combined with other modules for collective representation, or excluded from the model Modules such as the Ascent Digital Autopilot require significant time for execution, but involve no change in system state which would affect loading. On the other hand, modules such as Redundant Set Launch Processing Sequence cause a significant change of state when executed but involve only inconsequential execution time. Some modules are called by several other modules, such as Selection Filtering, while others are called by only one.

Software is described for IMSIM in terms of schedulable "tasks", loadable "routines", mathematical expressions or tables which yield execution time as a function of the model state, and logic sequences which manipulate the system state. It was necessary to map the salient software characteristics of the DDPS into IMSIM counterparts so as to retain a meaningful correspondence between system and model constituents, while conforming to the rules and constraints imposed by IMSIM (It should be noted that this situation is common to all modeling processes, regardless of the tools used, since a model is normally intended to be only a suitable approximation of an actual system)

Schedulable processes such as SPECS, OPS, and cyclic executives were designated as IMSIM tasks, and logic sequences were developed to activate and schedule them as a function of the simulated clock, externally introduced events, or the simulated system state (Major Mode or generated events). Program modules which are executed for a specific task, or for a specific set of tasks, were collectively described as "routines" For each routine, a mathematical algorithm was prepared which indicates the amount of computation to be simulated when a task which employs the routine is activated, as a function of the system state at the time of activation More than one routine may be employed in performance of a task For each DDPS program module which significantly alters the system state when executing, a similar change was programmed into IMSIM as a logic sequence, and was synchronized for concurrent execution with the appropriate task

Sizing of program modules was not a significant factor for the model, since dynamic memory allocation and loading are not characteristics of the ascent phase(OPS 1) of OFT. They therefore have no impact on system loading. (Flight

phase transitions involving phases which precede and follow the ascent phase (OPS 1) would involve memory management considerations However, such transitions were outside the scope of this study.)

Data transmission within the DDPS is described to IMSIM in terms of "messages". A message can define a set of transmissions, whether parallel or sequential, and with varying origins and destinations. All transmissions simulated for the DDPS are between the memory of a GPC and some other unit (e.g., a MDM or PCMMU, or even another GPC memory in the case of intercomputer communication). Similar transmissions, such as reading of data from the three IMUs, are described by a single message which represents concurrent transmissions from FF01, FF02, and FF03 (see appendix E for abbreviations) to the GPC memory. Messages are associated with tasks and are synchronized to task performance; e.g., if performance of a task is deferred or interrupted for higher priority processing, its associated transmissions may be delayed (but not interrupted).

1.4 APPLIED WORKLOADS

The workload specification for the DDPS model is actually an integral part of the software representation as discussed in section 1.3, but it must be activated and controlled by an event schedule which effectively specifies parametric values for the simulated software. For each Major Mode, an "Event mask" was developed that contained every event that would normally occur in the ascent sequence in that Major Mode. For Major Mode 101 (Terminal Countdown) the event mask was set through the event schedule that formed part of the job-schedule. For Major Modes 102--First Stage, 103--Second Stage, 104--OMS 1 Insertion, and 105--OMS 2 Insertion, the event masks were set by the event generation logic that was incorporated in IMSIM for this study. The event scheduling was designed to provide a realistic sequence of events, although the time scale was compressed for the sake of efficiency. The compression reduces the simulated time between events but provides sufficient intervals to permit loading peaks caused by the events to run themselves out. Details concerning job schedules and scenarios appear in section 5.2 4.

1 5 DYNAMIC SIMULATION

SDC performed a series of computer runs with the DDPS model for validation and verification against predicted performance under normal loading. The automatic monitoring and data reduction facilities of IMSIM were augmented with special software probes and reports to obtain the maximum of useful information from the runs, and to simplify extrapolation of results to predicted performance of the DDPS. IMSIM is a discrete event simulator and generally functions in a deterministic mode, although random behavior can be simulated by drawing pseudorandom numbers from built-in random number generators. Randomness was incorporated in the delivery of calculated execution times for some routines and is discussed in sections 5.1.4.2 and 5.2.1.4.

One major simplification of DDPS simulation was introduced for the computer runs. Since four of the General Purpose Computers (GPCs) of the DDPS are all organized as a redundant set for the OFT, they must necessarily perform

identical functions in close synchronization. In fact, the GPCs are precisely synchronized in the model unless a perturbation is explicitly introduced. Thus, no additional information is obtained from simulating the functions of four GPCs in a redundant configuration as opposed to a single GPC insofar as processor loading is concerned. Since simulation of parallel computations must be performed serially on a simplex computer, it is both cost-effective and efficient to eliminate the redundancy in the model. Note, however, that intercomputer communication is still simulated among the four GPCs in order to achieve a realistic load on the ICC data buses and to properly represent ICC activity for the GPCs.

Another major simplification was introduced for most of the computer runs. During the first of the series of simulation runs, SDC determined that the input-output activity associated with the principal functions has negligible loading impact on the CPUs Since most of the input-output logic is handled by the IOPs, the only expected effects were some interference between an IOP and a CPU in accessing memory, and idling of a task while it awaits I/O completion Some runs were performed both with and without simulated data transmission to verify that CPU loading due to transmission is insignificant, and simulation of transmission was omitted in subsequent runs. This change greatly speeded up simulation and allowed effort to be concentrated on execution of principal functions by the CPU.

Data produced from each simulation run include a history of the important events and activities, a summary of the final state of the model, and statistics on resource utilization and software functions Snapshot dumps were often taken of the dynamic state of the model in order to investigate particular situations in more detail

1.6 SIMULATION ANALYSIS

Results of simulation runs were analyzed in accordance with the approach depicted in section 5 1 4 5 to determine how the simulated DDPS performed under specified workloads and what workload variations should be considered for subsequent runs The data from history outputs (see appendix C) provide specific information on task contention for resources and the maximum interference in performing each type of task The history output also provides valuable insight regarding patterns of behavior in DDPS operation and situations of peak strain. The summary results (see appendix D) provide information on backlogging of tasks for CPU service, delays incurred in performing I/O, system component utilization, and statistics on contention for resources System status information yielded clues as to potential system behavior under different conditions, which could then be imposed for subsequent simulation runs. In consequence, data were accumulated from the series of runs which describe the DDPS model behavior and performance under a variety of stress situations. Subject to the conditions and assumptions detailed in section 5, SDC is confident that the model accurately reflects the operation of the DDPS, and that the results described in section 2 are indicative of the expected operational performance of the DDPS for the OFT ascent phase

2 RESULTS

A series of simulation runs was made with the DDPS model to determine performance during the Ascent phase of the OFT. Since it was not practicable to simulate the entire OPS 1 (even with limited variations), portions of the sequence were identified as being of special interest and a variety of runs performed for them The periods of OPS 1 selected for study† are shown in figure 2 1 They include the part of the Terminal Court (MM101) between Events 6 and 15, the transition to First Stage Flight (MM102) from SSME start (Event 17) through activation of the SRB separation monitor (event 25), transition to Second Stage Flight (MM103) beginning with function moding for separation (Event 27) and proceeding through enablement of MPS dump (Event 33A), and transition to OMS Insertion (MM104) until OMS ignition command (Event 37)

2.1 DATA TRANSMISSION

Several runs were made to determine DDPS loading due to data transmission, including intercomputer communication The heaviest loading was obsered for the simulated period of the Terminal Count (MM101) for reasons which are discussed in section 2 3 The results for this period are presented in table 2.1 Notably,

PCMMU #1 and its bus showed	24% utilization,
ICC buses showed	17% utilization, and
Display Electronic Units showed	17% utilization

PCMMU and ICC figures compared reasonably well with results obtained from the DDPS Loading Analysis for the ALT (see reference 5) which showed 18% and 15% respectively The new figures result from refinement of the workload specifications for the model, and are more accurate

The 7% utilization of memory for transmission shown in table 2.1 is not as significant as it might appear The access rate for memory is considerably greater than the addressing rate of which the CPU is capable, and, therefore, the rate of processing is not noticeably affected by memory "cycle stealing" for transmission

Several comparative runs were made with and without simulation of data transmission to determine the impact of transmission on execution of principal functions The only effects to appear were in delays of up to 2 ms in starting principal functions at their appointed times, and task waiting periods of up to 5 ms for end of transmission Since the former can be considered as scheduling offsets for cyclic processes, and the latter do not affect processing, the majority of simulation runs were conducted without simulating transmission in order to concentrate attention on processor utilization and performance of principal functions

†The selection process is described in section 5.2.4.

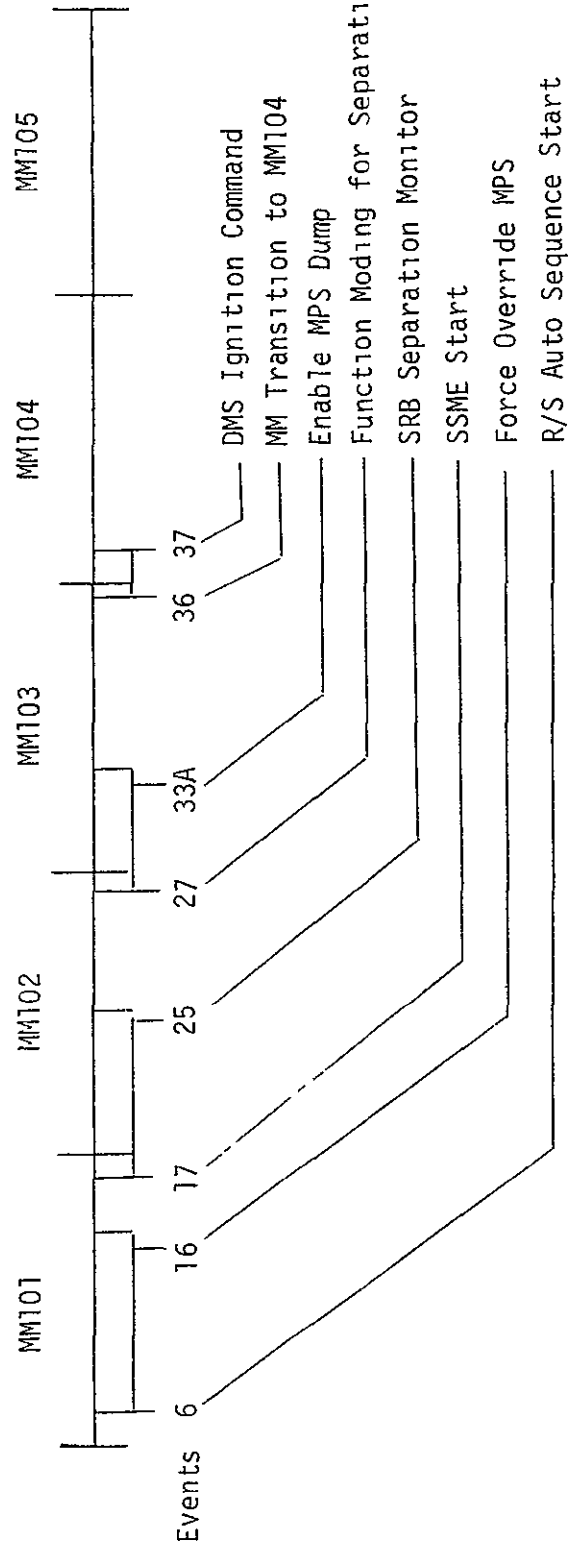

Figure-2-1 - Periods of OPS 1 Selected for Simulation

Table 2-1. DDPS Loading due to Data Transmission

Component		Average Transmission Period (ms)	Percent Utilization
GPC Memory		-	7 [3]
PCMMU1		8	24
HDRIs	DEU1	17	17
	DEU2	17	17
	DEU3	17	17
	FF1	- [4]	0
	FF2	- [4]	0
	FF3	- [4]	0
	FF4	- [4]	0
	FA1	0.03	1
	FA2	0.03 [4]	1
	FA3	- [4]	0
	FA4	- [4]	0
	LL1	- [4]	0
	LL2	- [4]	0
	LR1	- [4]	0
	LR2	- [4]	0
	EIU1	0.13 [2]	3
	EIU2	0.33 [2]	3
	EIU3	1 [2]	3
Buses and Channels	IC1	4	17 [1]
	IC2	4	17 [1]
	IC3	4	17 [1]
	IC4	4	17 [1]
	DK1	17	17
	DK2	17	17
	DK3	17	17
	FC1	0.02	2
	FC2	0.02 [4]	2
	FC3	- [4]	0
	FC4	- [4]	0
	FC5	0.13	3
	FC6	0.33	3
	FC7	1	3
	FC8	1 [4]	0
	LB1	- [4]	0
	LB2	- [4]	0
	IP1	8	24

Notes

1 IC figures are averaged
2 EIU figures are inferred from FC5, 6, 7
3 GPC% includes 1% for ICC
4 Insignificant

2 2 PERFORMANCE OF COUNTDOWN SOFTWARE

Simulation of the Terminal Count phase (MM101) indicates some problems in executing low-priority functions on schedule. Prior to Event 14 (T-8 sec), CPU utilization is less than 90%, but the peak loads which occur every 1000 ms interfere with Cyclic Display Processing, causing it to miss a cycle The average delay incurred by principal functions in obtaining CPU service is 20 ms, including delays for scheduling and following interruption for execution of higher priority functions. These delays affect the lower priority functions which generally have the larger cyclic periods, thus, the delays are not especially significant Furthermore, suitable offset scheduling can reduce these delays considerably

Cyclic Display Processing was assigned a very low priority even though it is on a 100 ms scheduling cycle It is probable that a suitable upward shift in its priority would allow it to complete operation in every cycle, without causing abortion of other functions

Subsequent to Event 14, Ascent Navigation is activated every 4 seconds This principal function (15) is a heavy user of the CPU and it occupies all available CPU time for a varying period every 4 seconds. The period is roughly estimated to be 1 second, depending on randomness incorporated in the Ascent Navigation computation time and the CPU requirements of higher priority functions It should be noted that activation of Ascent Navigation occurs at the confluence of all cycles except the 320 ms cycle; however, the latter occurs 160 ms afterward, and also contributes to overloading in this situation.

The effect of the overload is to inhibit performing of any principal functions below priority level 38 for roughly 1 second out of every 4 The panel labeled "MM101" in table 2-2 provides a summary of activity for the principal functions during a compressed-time simulation of the countdown from T-19 seconds to T-5 seconds Although the overload condition is apparent from the entries at priority levels 36 through 6†, the time compression distorts the results In fact, CPU percentage for function 14 (Ascent Navigation) extrapolates to approximately 15%, with a corresponding decrease in CPU idle and CPU utilization for lower priority functions While more function activations would be recorded in an expanded-time simulation, the number of missed cycles would also increase for functions below priority level 38. Above this priority level, the number of activations would also increase, but there would be essentially no other changes.

Simulation of the Terminal Count phase shows an 89% loading of the duty cycle of the CPU The above -mentioned problems highlight the fact that this is an overall average, and that for periods of 1000 ms or more, the CPU is 100% loaded Obviously, the CPU usage would be greater than 89% if the additional execution time for aborted functions were included. This loading exceeds the system performance requirement for CPU usage, stated as 70% in reference 10.

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†In IMSIM, a higher numerical value for a priority level indicates a higher execution priority.

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Table 2-2. DDPS Principal Function Performance for Nominal Ascent

Priority Absolute	Principal Function	Cycle Time (ms)	MM101			MM101 → MM102			MM102 → MM103			MM103 → MM104		
			Activations		% CPU	Activations		% CPU	Activations		% CPU	Activations		% CPU
			Required	Missed	Time	Required	Missed	Time	Required	Missed	Time	Required	Missed	Time
180	307	40	38	0	7 1	50	0	7 1	56	0	7 0	14	0	7 3
178	306	40	38	0	0 1	50	0	0 2	56	0	0 2	14	0	0 2
176	309	40	38	0	8 2	50	0	8 6	56	0	8 3	14	0	8 0
172	165	40	0	-	-	48	0	1 1	56	0	1 2	0	-	-
170	181	40	38	0	1 2	50	0	1 8	56	0	1 4	14	0	1 6
166	36	40	0	-	-	0	-	-	14	0	6 0	0	-	-
164	116	40	0	-	-	0	-	-	7	0	0	7	0	0 7
162	115	40	0	-	-	6	0	0 1	7	0	0 1	0	-	-
152	182	40	0	-	-	0	-	-	0	-	-	1	0	0
150	176	40	38	0	22 8	50	0	55 8	49	0	31 7	1	0	2 5
146	65	40	0	-	-	0	-	-	7	0	0 1	14	0	0 5
144	64	40	0	-	-	0	-	-	7	0	0 2	14	0	1 1
142	62	40	38	0	2 2	50	0	1 8	7	0	0 3	1	0	0 2
140	60	40	38	0	2 7	50	0	2 9	56	0	2 6	14	0	2.5
136	41	40	38	0	1 7	50	0	1 7	7	0	0 2	1	0	0 2
134	40	40	38	0	2 2	50	0	2 3	56	0	2 4	14	0	2.4
130	201	40	0	-	-	0	-	-	0	-	-	14	0	18 8
128	50	40	38	0	3 0	50	0	3 4*	56	0	3 0	14	0	2 9
124	175	40	0	-	-	48	1	3 0*	56	0	3 7	14	0	3 1
122	97	160	3	0	0 9	13	0	1 3	14	0	1 4*	4	0	2 8
120	203	40	38	0	2 5	50	4	2 2	7	1	0 3*	1	0	0 2
118	188	40	5	0	0 1	0	-	-	0	-	-	0	-	-
116	190	40	0	-	-	0	-	-	14	0	0 8	14	1	3 5*
115	193	40	0	-	-	48	13	2 2	7	1	0 6	0	-	-
114	187	40	0	-	-	0	-	-	0	-	-	0	-	-
113	164	40	0	-	-	7	2	0	0	-	-	0	-	-
112	91	40	38	0	3 2	50	25	1 4	56	3	3 5	14	1	3 5
110	52	40	38	0	1 2	50	36	0 1	56	7	1 0	14	1	1,6
108	120	40	37	0	2 9	50	39	0 6	7	5	0 1	1	0	0 4
106	119	40	37	0	2 0	50	41	0 4	55	7	1 7	14	1	1 5
102	92	40	0	-	-	0	-	-	0	-	-	1	0	0
100	42	40	37	0	2 1	50	44	0 2	7	5	0 1	1	0	0
68	114	80	19	0	0 6	2	0	0 1	1	0	0	1	0	0 2
67	54	80	0	-	-	0	-	-	4	0	0	7	0	0 2
65	333	40	37	0	3 8	3	0	0 2	0	-	-	0	-	-
62	171	80	0	-	-	0	-	-	0	-	-	7	0	1,3
60	180	80	19	0	1 2	25	20	0 2	28	3	1 1	7	0	1 3
55	334	demand	0	-	-	0	-	-	0	-	-	0	-	-
52	45	160	0	-	-	0	-	-	0	-	-	2	0	0 2
50	49	160	10	0	0 2	13	11	0 1	14	1	0 4	4	0	0 5
48	183	160	0	-	-	0	-	-	0	-	-	4	3	0
46	161	160	1	0	0	1	0	0	0	-	-	2	0	0 2
44	70	160	0	-	-	0	-	-	1	-	-	4	0	0 2
40	19	var	1	0	0	1	0	#	2	0	0 1	1	0	0
38	15	4000	1	0	6 6	1	0	1 2	1	0	15 2	1	0	0 5
36	168	160	3	2	0 2*	13	12	#	14	9	0	4	3	#
35	332	200	8	1	0 3	10	9	#	12	7	0 3	3	2	#
34	3	2000	0	-	-	0	-	-	0	-	-	1	0	#
33	2	2000	0	-	-	0	-	-	1	0	0 7	0	-	-
32	1	160/500	0	-	-	6	5	#	1	0	0 1	0	-	-
31	319	320	5	0	1 1	7	6	#	7	5	0 4	2	1	#
30	95	320	5	0	0 1	7	6	#	7	5	0	2	1	#
25	110	1000	2	0	0 5	2	1	#	3	1	0 4	1	0	#
23	102	1000	2	0	0 3	2	1	#	3	1	0 1	1	0	#
21	101	1000	2	0	0 1	2	1	#	3	1	0 1	1	0	#
19	337	1000	2	0	0	2	1	#	3	1	0 1	1	0	#
12	197	2000	1	0	0	1	0	#	2	0	0	1	0	#
10	335	100	15	4	8 0	20	19	#	23	19	1 6	6	5	#
8	210	2000	0	-	-	0	-	-	0	-	-	1	0	#
6	206	2000/500	1	0	0	1	0	#	2	0	0	1	0	#
	Idle				11 0	-	-	0	-	-	1 7			0
	Total		747	7	100	1088	297	100	962	82	100	294	19	100

#No CPU service

*Function abortions below this point

2.3 PERFORMANCE OF FLIGHT SOFTWARE

A more serious situation pervails in the observed performance of the DDPS model during first and second stage flight (MM102 and MM103). The CPU becomes saturated upon transition from Terminal Count (MM101) to First Stage Flight (MM102) and remains in this condition for the periods of MM102 and MM103 that were studied (see figures 2-2 and 2-3) As a consequence, certain principal functions do not complete execution within their duty cycles. In the DDPS model, such a development manifests itself through the abortion of any principal function which is scheduled when it has not yet completed execution for a previous cycle. Functions are never cancelled, only deferred, so, normal operation of the model shows the number of times functions were aborted, but not the degree to which CPU requirements are exceeded.

Table 2-2 shows a performance summary of functions during portions of MM102 and MM103 for a nominal ascent profile Note that functions begin aborting ("Missed" column) at absolute priority level 124 in MM102 and at 118 in MM103. These correspond to the Guidance/Control Steering Interface and SRB Data Acquisition, respectively The proportion of abortions progressively increases through lower priority functions until level 50. Functions with absolute priorities below 50 never complete a cycle in MM102

Table 2-2 also shows the percentage of total CPU time used in the execution of each function. Since the CPU becomes saturated, these figures should only be used to compare the relative CPU requirements of functions which suffered no abortions It is evident from inspection of the table that Principal Function 176--the Ascent Digital Autopilot--is by far the greatest employer of the CPU, with Principal Function 15--Ascent Navigation--a significant second during MM103

Because of CPU saturation, it is pointless to attempt to analyze DDPS loading under other conditions (i e , for other than a nominal operational profile). Some simulation runs were made which include SSME failure (Vehicle Safing) and faulty thruster indication, but the results are not significant under the circumstances Furthermore, statistics on data transmission and data bus utilization are of little value, since transmission initiations are distributed among most principal functions Transmissions related to the high-priority functions are adequately covered by simulation of the Terminal Count phase, and other transmissions are not accurately represented in the flight phases due to the CPU overload condition

In order to get some estimate of the CPU overload, a series of simuation runs were undertaken with a modified DDPS. The CPU processing rate and the GPC memory access rate were increased by a factor of 4, i e., the CPU rate was set at 1920 instructions/ms and the memory access rate at 5600 bytes/ms. The results of these runs are shown in table 2-3 At the artificially high execution rate, the CPU shows approximately 30% utilization and some functions are still aborted (viz , Cyclic Display Processing is aborted every 4 seconds,

Table 2-3. Principal Function Performance with a Hypothetical 4XDDPS

Priority Absolute	Principal Function	Cycle Time (ms)	MM101 → MM102			MM102 → MM103		
			Activations		% of Used CPU Time	Activations		% of Used CPU Time
			Required	Missed		Required	Missed	
180	307	40	46	0	5 6	55	0	6.0
178	306	40	46	0	0 2	55	0	0 2
176	309	40	46	0	6 8	55	0	7 5
172	165	40	43	0	0 3	55	0	0 3
170	181	40	46	0	0 5	55	0	1 3
166	36	40	0	-	-	13	0	4 5
164	116	40	0	-	-	7	0	0
162	115	40	2	0	0 2	7	0	0
152	182	40	0	-	-	0	-	-
150	176	40	46	0	44 6	49	0	28 6
146	65	40	0	-	-	7	0	0
144	64	40	0	-	-	7	0	0
142	62	40	46	0	1 6	7	0	0 2
140	60	40	46	0	1 2	55	0	2.0
136	41	40	45	0	1 4	7	0	0
134	40	40	46	0	1 4	55	0	3 0
130	201	40	0	-	-	0	-	-
128	50	40	45	0	2 8	55	0	3 0
124	175	40	43	0	0 3	55	0	3 5
122	97	160	12	0	0 7	14	0	1 0
120	203	40	45	0	2 8	7	0	0 2
118	188	40	0	-	-	0	-	-
116	190	40	0	-	-	13	0	0 8
115	193	40	43	0	2 3	7	0	0 3
114	187	40	0	-	-	0	-	-
113	164	40	7	0	0	0	-	-
112	91	40	46	0	2 1	55	0	3 8
110	52	40	45	0	0 9	55	0	0 8
108	120	40	45	0	2 4	7	0	0 2
106	119	40	45	0	1 6	55	0	1 0
102	92	40	0	-	-	0	-	-
100	42	40	45	0	0 7	7	0	0 2
68	114	80	2	0	0	1	0	0
67	54	80	0	-	-	4	0	0
65	333	40	3	0	0	0	-	-
62	171	80	0	-	-	0	-	-
60	180	80	23	0	0 2	28	0	0 7
55	334	demand	0	-	-	0	-	-
52	45	160	0	-	-	0	-	-
50	49	160	12	0	0	14	0	0 2
48	183	160	0	-	-	0	-	-
46	161	160	1	0	0	0	-	-
44	70	160	0	-	-	0	-	-
40	19	var	1	0	0	2	0	0
38	15	4000	1	0	10 8	1	0	14 3
36	168	160	12	0	0	14	0	0 2
35	332	200	10	0	0	11	0	0 2
34	3	2000	0	-	-	0	-	-
33	2	2000	0	-	-	1	0	0 7
32	1	160/500	5	0	0 2	1	0	0 2
31	319	320	6	0	1 7	7	0	2 5
30	95	320	6	0	0	7	0	0
25	110	1000	2	0	0 3	3	0	0 5
23	102	1000	2	0	0 2	3	0	0 2
21	101	1000	2	0	0	3	0	0 2
19	337	1000	2	0	0	3	0	0 2
12	197	2000	1	0	0 2	2	0	0
10	335	100	19	0	5 9	22	1	12 0
8	210	2000	0	-	-	0	-	-
6	206	2000/500	1	0	0	2	0	0
	Total		990	0	100	948	1	100

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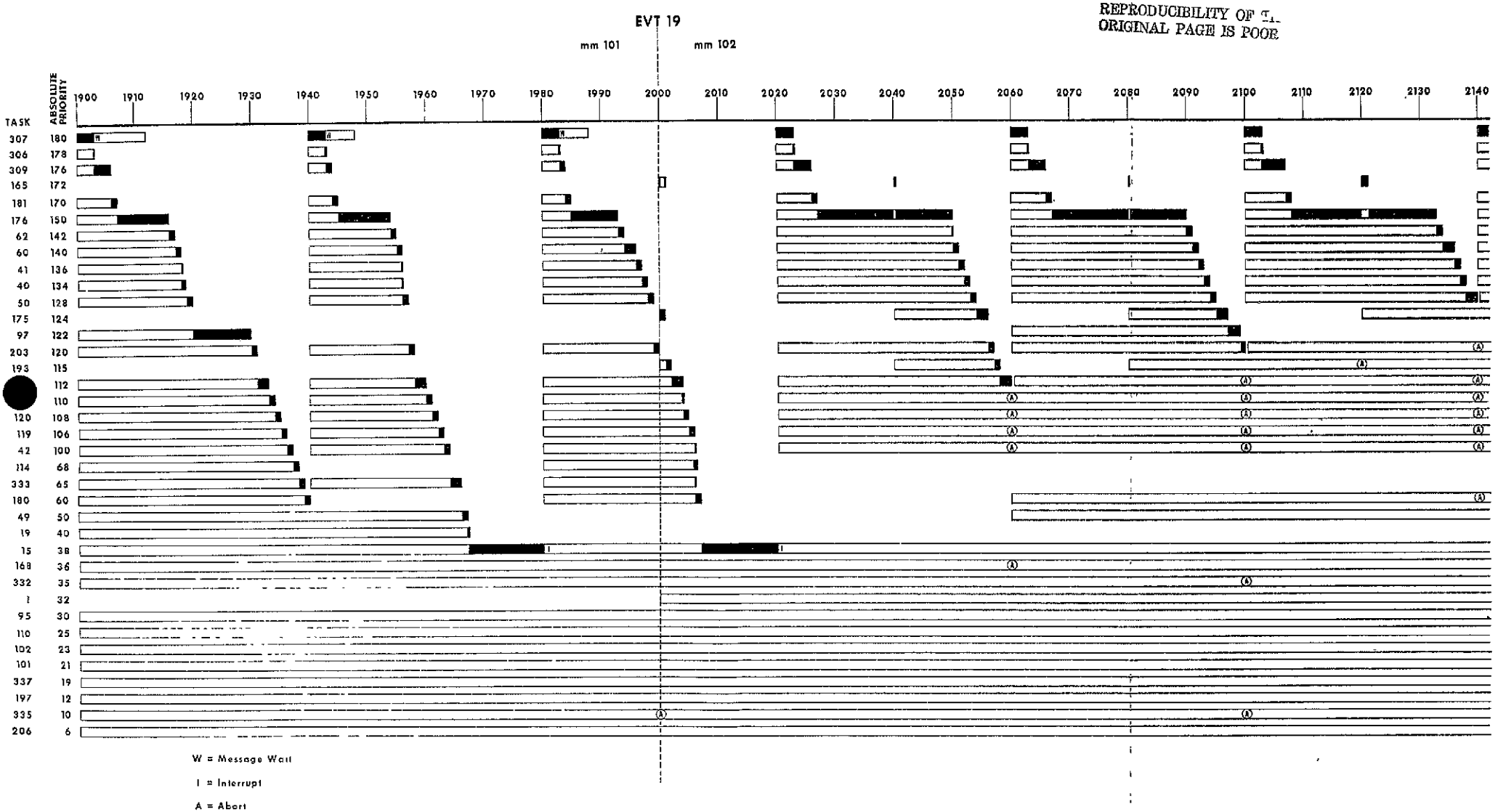

FOLDOUT FRAME 1

Figure 2-2. Timeline Graph for Transition MM101 to MM102

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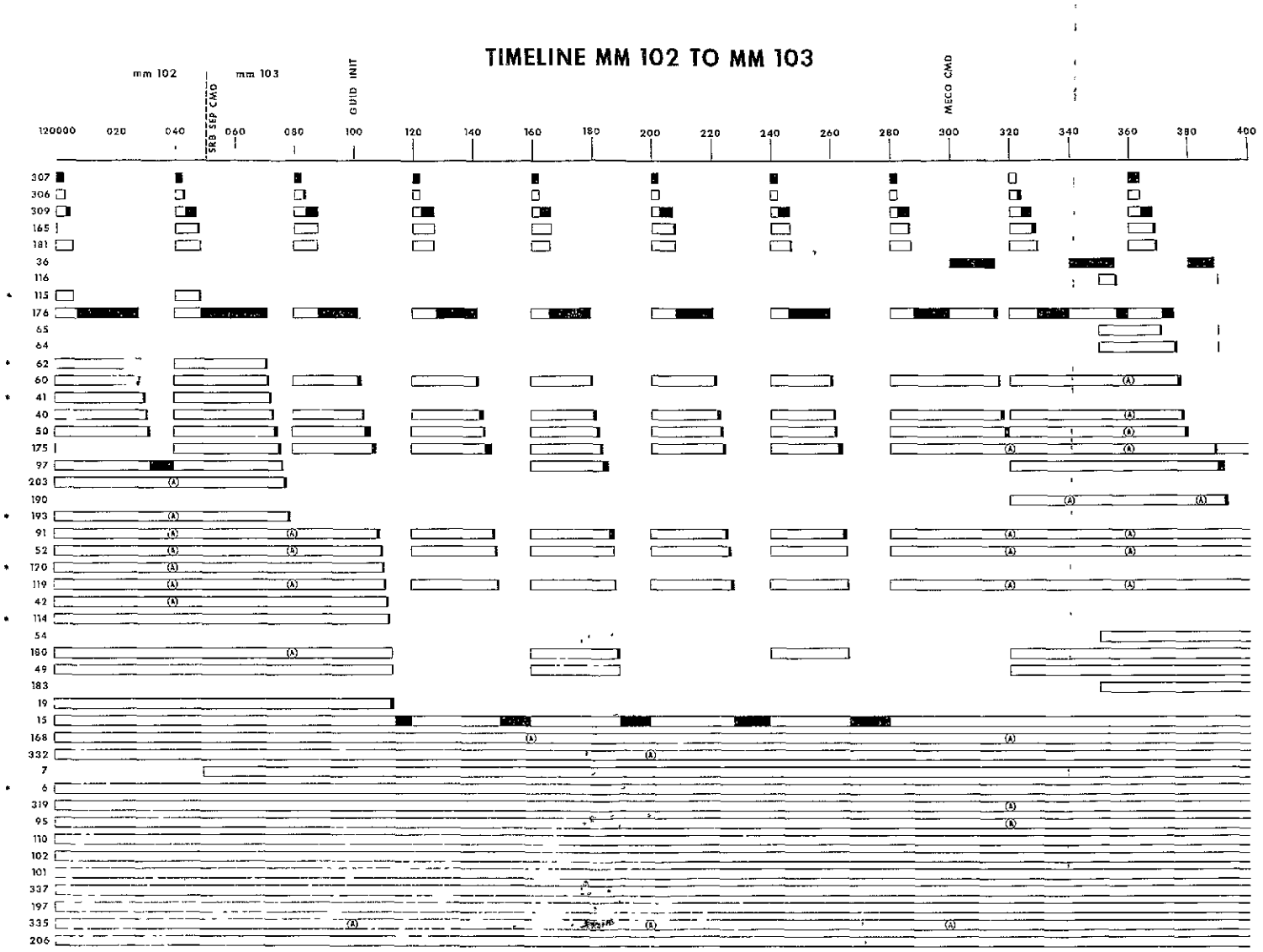
TIMELINE MM 102 TO MM 103



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* = Tasks operating in mm 102 only

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when Ascent Navigation is activated). These runs give a better idea of where the CPU time is being spent. Note that the Ascent Digital Autopilot still occupies 45% of the CPU time in MM102, and Ascent Navigation remains essentially constant at 14% in MM103

From the information obtained through high execution rate simulation, it can be determined that the CPU is overloaded by a factor of 1.8 during some major cycles of MM102 and by 2.3 in MM103. If the NASA requirement of a 30% reserve capacity is included for the CPU, the overload factor is 2.6 for MM102 and 3.3 for MM103. While this type of simulation run was not performed for MM104 (Orbit Insertion), it is apparent from the data in table 2-2 that a similar overload develops, with aborts beginning at priority level 116, corresponding to the Ascent RCS Command SOP.

Transport lag and initiation jitter for the flight control executive were not specifically investigated in this study, since they were analyzed in the earlier ALT dynamic loading analysis (see reference 5), and the analysis is valid with respect to OFT.

3 CONCLUSIONS

3.1 SYSTEM CAPACITY

The data bus network is only lightly loaded and is configured so that virtually no message congestion occurs. The ICC buses operate at capacity during memory-to-memory transmission and impose the most significant I/O loads on memory during a 2 ms period of every 40 ms cycle; however, this is estimated at 60% of memory accesses for 5% of the time, or 3% of the capacity for memory access. Data buses are estimated to have reserve capacity for transmission in excess of 75%.

In summary, the capacities to perform data transmission in the GPCs and the data bus network appear adequate to support the countdown and ascent phases of the Orbital Flight Test.

Loading for the CPU appears to significantly exceed the 70% limit requirement imposed by NASA during the terminal countdown, and to greatly exceed the capacity of the CPU during first and second stage flight, as summarized in table 3-1.

Table 3-1. CPU Loading

	% CPU REQUIRED				
		MM102		MM103	
	MM101 General	General	Worst Major Cycle	General	Worst Major Cycle
100% CPU Available	89	128	180	108	230
70% CPU Available	127	183	257	154	329

In fact, even the total capability of the CPU is inadequate for the ascent functions. Of course, these observations are based on the detailed assumptions and estimates regarding principal function operating characteristics included in sections 5 1.4.2 and 5.2.1.4; in particular, the values are sensitive to estimated computation time for the Ascent Digital Autopilot, Ascent Navigation, and Cyclic Display Processing.

Given the above information, we conclude that NASA requirements for OFT software as presently detailed in references 6 through 12 cannot be met by the DDSP under the operating constraints imposed in reference 18.

3.2 RESPONSE CHARACTERISTICS

Since the System Software Interface Processor is assigned the highest priority of scheduled processes, it is executed on schedule and can respond to I/O completion with virtually no delay Offset adjustments in the schedules for the second and third highest priority cyclic processes--the Fast Cycle Executive and the Minor Cycle Executive--should make it possible for both of these processes to execute on schedule, and for the Fast Cycle Executive to respond immediately to I/O completions

Response of other processes generally deteriorates as priority decreases. Because of the CPU overload, responses can only be meaningfully discussed in regard to the highest priority processes. While these experienced delays of up to 20 ms, offset scheduling can probably reduce the delays to less than 10 ms.

4. RECOMMENDATIONS

The recommendations presented in this section reflect the results of analyses of the simulation runs performed under this study and indicate suggestions relating directly to the planned OFT hardware and software, as well as recommendations for effective expansion of this study effort. Section 4.1 deals with specific configuration recommendations, while section 4.2 presents a summary of augmented study tasks to refine these analyses and to investigate related aspects in other flight phases

4 1 DDPS CONFIGURATION RECOMMENDATIONS

The CPU overload situation discussed in section 3 calls for a careful review of assumptions and timing estimates used in the DDPS simulation, and prudence dictates at least preliminary effort toward reducing the CPU load requirements during the flight phases of OFT In both of these activities, emphasis should be first directed to the principal functions which appear to place the most severe loading on the CPU during critical periods, viz , the Ascent Digital Autopilot (DAP, Ascent Navigation, and the Cyclic Display Processor.

SDC recommends that the following methods of attack be considered:

- Reassess the estimated computation times and derivations as given in section 5 2.1.4
- Reassign priorities to give heavy CPU users the lowest possible priorities, consistent with criticality and frequency of execution.
- Restrict the execution of subfunctions of the principal functions to multiples of the fundamental cycle period of execution of the function, as is done through use of Hybrid Dispatcher in the Approach and Landing Test (ALT) software
- Reconsider required execution rates for some of the more time-consuming principal functions
- Reexamine the total OFT software package, with a view toward eliminating nonessential processing
- Shift nonessential processing and functions which do not require full redundancy for reliability to the backup GPC.
- Reduce DDPS redundant operation to obtain more CPU power

4 2 AUGMENTATION OF SIMULATION EFFORTS

The dynamic, discrete simulation model of the DDPS was developed by SDC to fulfill the objectives of the DDPS study Its operation has been verified and validated against requirements and available performance data. SDC recommends its continued use as a device for experimenting with scheduling algorithms and applied workloads for the DDPS under a variety of conditions which would be difficult or impossible to verify prior to actual flight. The monitoring and reporting facilities of the model could not be effectively incorporated in the real system, no other approach can enable system designers to obtain more insight into the dynamic behavior of the DDPS during its development. Use of the model also provides project management with an overview of the dynamic, as well as static, character of the DDPS

4 2 1 Extended Studies for OFT Ascent Operations

a Continued use of the model should be performed on the Ascent phase (OPS 1) configuration to include solutions to the apparent problems of software execution uncovered during this study, as well as to incorporate up-to-date information on detailed design specifications and refined estimates of program module timing Any of the alternatives or combination of alternatives given in section 4 1--DDPS Configuration Recommendations--that are considered as desirable options to alleviate the problem of software execution under normal conditions should be modeled and simulated to verify that they actually resolve the execution problem

To accomplish an extended analysis of Guidance, Navigation, and Control functions, some changes to the existing parameterized model will have to be made Most of the hardware specification parameters (IMSIM forms 6 through 14) will remain unchanged If necessary, speedfactors and access times can be changed with ease Some of the software workload parameters, however (IMSIM forms 2 through 5), will require more extensive modification Reassessment of the estimated computation times given in section 5 2 1 4 may require modification of parameters on input form 3 and in the Variable Expressions file Reallocation of priorities to Ascent DAP and Ascent Navigation will require changes to the parameters on input form 2, changes to the Variable Expressions file, and new logic to be incorporated in IMSIM Reconsideration of lower function execution rates will require changes to the activation logic described in section 5 2 1 3 Elimination or combination of certain functions, resulting from reexamination of the total software package will require changes to parameters for input forms 1, 2, 3,and 5

Efforts to be accomplished should include aspects of the following activities, as were performed under this study

1 Requirements analysis

2 Test design

3 Model adaptation and parameterization

4 Model execution

5 Test analysis and documentation

b Further effort should be expended to determine the greatest stress situations which can develop during the OFT mission, and results should be employed in constructing associated workloads for the model Additional conditions which should be investigated via simulation include system errors and component failures. Once the normal execution of all Principal Functions within their prescribed cycles is accomplished, the uncommon situations, such as Vehicle Safing, OMS failure, etc , should be simulated according to precise schedules to achieve maximum impact

4 2 2 Investigations of Entry, RTLS, and Orbit Operations

a Detailed simulations and analyses should be conducted into OPS 3 (Entry Operations) and OPS 6 (Return to Launch Site Operations), at a sufficient level of detail to assess the performance characteristics of these critical phases during high load conditions These simulations would be a natural evolution from OFT Ascent Operations loading analyses, since all OFT hardware components of the model, a subset of the OFT applications software, and the DDPS execution logic have already been developed and validated. In addition, several unique features have been incorporated into the IMSIM logic to more accurately model the specific characteristics of the DDPS. These capabilities will all be instrumental in effectively assessing the throughput and loading performance of the DDPS during Entry and RTLS. Moreover, since the development of applications software for these operations is nearing completion, reasonable estimates of program execution times can be employed to provide additional confidence in simulation run results

As has been done for OFT Ascent Operations and the ALT configuration, such simulations should be employed to evaluate the effects on the DDPS throughput performance due to the interaction of the GPCs, the data buses, the various BTUs (bus terminal units) when driven by the software needed to meet the functional requirements identified for these operations. The end product of this activity should be a detailed analysis of the orbiter DDPS performance during applicable modes, identifying areas or functions with high probabilities of incurring degradation due to overloading of the DDPS during periods of high dynamic activity.

b A further logical extension of the OFT Ascent Operations studies would involve the throughput analysis of OPS 2 (Orbit Operations), and possibly OPS 4 (Atmospheric Operations), if this latter phase is actually incorporated into orbiter capabilities as a distinct operational phase

As was stated above for Entry and RTLS Operations, such simulation analyses should be based on the currently available IMSIM simulation model which has been extensively adapted and parameterized for OFT analysis. As additional applications software is produced to accommodate these operations, expected program execution times can again be incorporated as model input parameters to provide more accurate representations of software component characteristics.

c Specific IMSIM loading studies should be performed to assess the performance of the DDPS when transitioning from one OPS to another In contrast to the studies outlined in a and b above where memory management is not a consideration (i e , all pertinent software modules are assumed to be core resident during the operations), main memory loading and consolidation may pose new problems during OPS transitions Particular reconfigurations that should be studied are as follows

1 From OPS 1 (Ascent Operations) to OPS 2 (Orbit Operations).

2 From OPS 2 (Orbit Operations) to OPS 3 Entry Operations) with return to OPS 2 (event 61)

3. From OPS 3 (Entry Operations) to OPS 4 (Atmospheric Operations)†.

4 From OPS 1 (scent Operations) to OPS 6 (Return to Launch Site Operations)

5 From OPS 6 (Return to Launch Site Operations) to OPS 4 (Atmospheric Operations) †

Such simulations should emphasize software loads occurring before and after reconfigurations, with particular attention being directed towards processor utilization, data bus utilization, and task completion delays that may result from these transitions

d Operational Flight Test requirements for the DDPS should be analyzed from a dynamic functional standpoint to determine behavior with an additional simplex (nonredundant) mode GPC and software execution for new major functions and modes The impact of additional dynamic loading for activities such as uplink-downlink, fault detection, and payload monitoring should also be investigated

e While the DDPS model is well suited to the investigation of dynamic functions at a resolution of 1 ms, it should not be used at other appropriate time scales to represent specific functions of the DDPS. Functions which are independent of each other, or at least series-related, should be individually modeled as required to observe their individual behavior

†Applicable only if OPS 4 is eventually incorporated as a distinct operational phase for OFT

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SDC has designed the DDPS model to represent the functions of the GPCs, the bus network, and bus terminals as an integrated system in which feedback is an essential characteristic. Localized activity, such as occurs in DEUs, IOPS, and PCMMUs, may normally have negligible impact on the DDPS operational at the 1 ms level of discrimination, but may still require simulation to determine situations in which they become saturated or otherwise loaded so as to change their operating characteristics and affect general system performance The precise steps by which the Process Management component of the Flight Control Operation System monitors events and schedules processes should be simulated in detail to determine performance and dynamic loading conditions, and used as an aid in making systematic, effective improvements in scheduling algorithms and methods of implementation. In this manner, a variety of aspects of synchronous and asynchronous approaches can be evaluated effectively.

f. SDC also recommends that consideration be given to the construction of new specialized models of system components to study their behavior through simulation on appropriate time scales (e g , to a microsecond level) Such models may be built using IMSIM, as was the DDPS model, or they may be constructed using the underlying general-purpose simulation package--MODLIT--upon which IMSIM is based Both of these tools may be used to construct models which can be operated dynamically by discrete simulation to yield useful data on behavior under conditions which are difficult or impossible to duplicate in real systems Furthermore, processes such as intercomputer communication may be represented at more than one level of time resolution in different models For example, one model can be used to determine "macroscale" characteristics for inclusion in another model which uses a finer resolution factor.

5. TECHNICAL DESCRIPTION

The following paragraphs describe in detail the objectives of the Timing Sensitivity Analysis Study and the efforts performed under each of the tasks defined in section 3 of the Statement of Work

5 1 INTRODUCTION

High-speed digital computers have been increasingly applied to the analysis and design of complex systems One of the most useful techniques for such applications is that of discrete simulation, in which the system is represented in the computer as a dynamic model which changes its state with the stepwise passage of simulated time

The IMSIM model has been developed to aid in the investigation of systems which include computers It is constructed upon the MODLIT Discrete System Simulator In effect, IMSIM is a general model of a computerized transmission system, which can be tailored to represent a wide variety of configurations, components, and applied loadings. Furthermore, as a fully interactive model, it enables the user to monitor its behavior and to make dynamic modifications during simulation

The objectives of the Timing Sensitivity Analysis Study and the model goals are presented in section 5 1 1 The guidelines and assumptions for the model development are delineated in section 5.1 2. A brief conceptual overview of IMSIM is given in this introduction in section 5 1 3, and the overall approach to the model development, applied workloads, and dynamic simulation is given in section 5 1.4.

5 1 1 Objectives and Model Goals

The primary objective of the Space Shuttle Orbiter Digital Data Processing System Timing Sensitivity Analysis effort is to investigate the dynamic behavior of the orbiter's data processing subsystem during the Ascent phase (OPS 1) of the already defined OFT in order to identify and formulate resolutions for critical performance areas

To meet this objective, the generalized IMSIM model was adapted and parameterized, so that the Space Shuttle's appropriate hardware and the software Principal Functions for OFT were properly represented in this model

The model goals were established as a result of the work performed under the Requirements Definition task (Statement of Work task 3 1).

From a study of the overall dynamic hardware and software data flow requirements it was determined that the IMSIM model should be constructed within the following set of basic goals

- The model should be configured so as to allow statistical data generation on the dynamic behavior of central processing units, which will be the focal point for analyzing system performance.
- Suspected potential data flow problem areas (defined by a Sensitivity Analysis) should be modeled such that data could be generated to determine if and/or to what extent these areas are critical in respect to system performance
- The model should be designed for the specific operational configuration (OPS 1 - Ascent phase) and include only that hardware and software required to simulate the functional dynamics required for that operation, i.e., Shuttle Orbiter Data Processing Subsystem characteristics such as operational reconfiguration, fail and fault redundancy, abort modes, and BITE should not be incorporated in the model.

5 1 2 Guidelines and Assumptions

5 1 2 1 Model Guidelines The following NASA-specified guidelines for the IMSIM model were defined in a project coordination meeting held August 11-13, 1976, and in subsequent coordination communications·

a The simulation model will be parameterized and adapted for the Ascent phase of the OFT configuration Major emphasis will be on Major Modes 101, 102, 103, and 104

b Events in Major Mode 101 will start at T-20 with event No 6--as specified in SS-P-0002-510D, Computer Program Development Specification, OFT Level B Guidar Navigation, and Control already used dated 30 August 1976, page 3-41

c Prelaunch events and activities prior to transition to Major Mode 101 will be provided by NASA for setting initial conditions.

d In the OFT Ascent phase, four GPCs will be in redundant mode, while GPC #5 will act as backup and will not be simulated

e The Manipulator Control Interface Unit (MCIU) is connected to the Launch Data Buses (LDB 1 and LDB 2), but need not be simulated.

f. Events can be scheduled in a condensed timeline These timelined events were sent to NASA for perusal and approval

g After the Solid Rocket Booster (SRB) Separation, event sequences can be set up with nominal time.

h. All critical phase software for the OFT Ascent phase will fit in core memory and no effort to size the programs or modules will be required.

i. No overlays will take place during the ascent simulation.

j Mass Memory will not be used during ascent simulation

k Specialist functions will not be invoked during the Ascent phase.

l Assumed priorities for OFT software functions were developed by SDC and sent to NASA for perusal and approval. The 40 ms functions should have the highest priorities

m Event 23 (Vehicle Safing) as specified in SS-P-0002-510 D on page 3-46, will be simulated during a high load activity period

n There will be no "simultaneous" failures during OFT. only one failure out of four components and then one failure out of three components can occur.

o Cyclic functions must complete in every cycle they are executed.

p The tentative hardware configuration diagram for OFT Simulation, prepared by SDC and submitted at the referenced meeting, was approved with some minor changes.

q NASA will try to provide SDC with the tentative computation times for the programs and modules contained in a list that was compiled by SDC and given to NASA on 14 September 1976

r The uplink capability for OFT OPS 1 need not be simulated.

s A sizing of each of the Principal Functions is to be provided to SDC as a contingent double check regarding program execution times

5 1 2 2 Assumptions Based upon the NASA-supplied guidelines, the OFT Level C FSSR Documents, and the OFT Computer Program Development Specifications, the following assumptions have been defined for the IMSIM model

- IOP control activity and its memory access for commands have negligible impact on system functions at the millisecond level of perception, and therefore are not simulated Data transmissions are associated directly with the processes which initiate or process them

†A key factor in simulated DDPS throughput performance has been the generation of assumed execution times for the various modules See Section 5.2.1.4 for a description of the approach used in determining these times, and the resultant times used in these modeling runs

- Only the processes within one GPC are simulated, based on the assumption that virtually identical loading of the CPU occurs in all members of a redundant set ICC traffic between all four GPCs is simulated, however, as if all four operate simultaneously Simulation of identical activity in all GPCs would simply increase operating times for simulation and would yield no additional information.

- The User Interface Control Supervisor is only simulated for MCDS messages and Applications service Completion of MM I/O service is excluded

- For Cyclic Display Processing (DCI_CYC_DISPLAY) and New Display Processing (DMC_NEW_DISPLAY) I/O is not suppressed for any DEU, displays are never frozen, and output is always a full page (509 words).†

- The GPC Downlist Formatter (DCD_DOWNLIST) is assumed to be enabled.

- The GPC/PCMMU Data Cycle Synchronizer (DCS_SYNC) will not be invoked during Ascent operations

- The DEU Loader (AIG/DEU/LOADER) will not be scheduled during the Ascent phase of OFT.

- No uplink capability will be simulated for the Ascent phase

- The downlink data rate will be at 128 Kbps

- The following System Control processes are not simulated because they are irrelevant to Ascent operations ASA, ASB, ASC, ASD, AIB, ARB, ARC, ARH †

- OFT memory configuration #1 can be accommodated in GPC memory with no capacity problems

- Task scheduling will be performed as follows

  - Processing is interruptible by the executive and critical tasks (IMSIM tasks of service class #1)

  - Critical tasks have precedence and confiscation privileges over noncritical tasks in obtaining processors.

  - Scheduling is determined by task priority

- All transmissions are to be over explicitly defined data links, and no implicit links are allowed

†See ALT Functional Design Specification Volume II Systems Software.

- The CPU will not be interrupted in performing a task in order to initiate and service I/O (this function is performed by the IOP of the DDPS)
- A time resolution of 1 ms is sufficient for the investigation of DDPC processes as specified by the SOW.
- Mass Memory Message Processing (DMP_MM_MSG_PROC) is not used during the Ascent phase of OFT.
- Reconfiguration does not occur during the Ascent phase simulation for OFT.
- MCDS Major Function change does not occur
- CMPTR/CRT and CMPTR/BUS keys are not used during the Ascent phase simulation for OFT.
- The ITEM DATA key sequence is not used
- New displays do not occur during Ascent
- Three DEUs are updated every 100 ms by Cyclic Display Processing (DCI_CYC_DISPLAY).
- The ICC Router (DME_ICC_ROUT) is referenced by the System Software Interface Processor (AIE_SIP)
- Each display update requires four scalar conversions and ten item formattings
- No downlist commands are issued during Ascent
- Main memory is adequate for all functions and data areas required during the Ascent operations of OFT, and no programs will be loaded or swapped during this phase
- When discretes are to be read from equipment through an MDM, all of the discretes of the particular equipment are read as a unit (16 bits at a time)
- The processes of the Principal Functions denoted as IMU_INT_PROC (Inertial Measurement Unit Inertial Processing - 4 38) and IMU_RM (Inertial Measurement Unit Redundancy Management - 4 72) are suitably incorporated in the Minor Cycle Executive and the IMU Major Cycle Executive, and these cyclic executives can be simulated as in the ALT model, while IMU_INT_PROC and IMU_RM need not be represented explicitly
- The selection filter execution for the Radar Altimeter SOP reads the RALT floating point words and condenses them to a single value for the SOP

- For the purpose of simulation, the Body Flap Enable Commands issued by AERO_ACT_SOP (4 50) can be directed to Aerosurface Servo Amplifiers (ASA) 1 through 4.

- The rudder and speedbrake commands are not issued by AERO_ACT_SOP (4.50) during Ascent

- FCS channel override/bypass commands and body flap commands need not be explicitly represented by transmissions but can be included in transmissions for inboard/outboard elevon commands

- Power on discretes need not be read by explicit transmissions in the model (See reference RA_SOP 4 45).

- ATVCD channel override commands will not be simulated in execution of the MPS TVC Command SOP (4 60)

- ATVDC servo valve override commands will not be simulated in execution of the SRB TVC Command SOP (4 62).

- No STOP command nor abort control sequence occurs during dump (MPS_DUMP 4 70)

- The Selection Filter principal function (SF 4 71) is not scheduled per se, but is called by other principal functions to perform specific filtering as follows

Function	Para	Filtering
ORB_RG_SOP	(4 40)	SF(RGA) RG
SRB_RG_SOP	(4 41)	SF(SRB RG) LT SRB RG, RT SRB RG
AA_SOP	(4 42)	SF(AA) AA
RA_SOP	(4.45)	SF(RA) RA
BF_PFB_SOP	(4 49)	SF(PFB) FEEDBACK
3-AX_RHC_SOP	(4 171)	SF(RHC) LH/RH RHC ROLL/PITCH/YAW CMD
DELTA_P_F/B_SOP	(4 193)	SF(ELVN PRESS XDUCER) L/R INBD/OTBD ELVN PRESS FB

- Operating priorities are assigned to Principal Functions as indicated in section 5 2 3 3

- In writing Main Engine commands, one command word is transmitted to each EIU for each cycle of the task

- In reading Main Engine status from EIU 1, 2, and 3, all status data words are read in every cycle of the task

Footnote

Numbers in parentheses indicate paragraph numbers in Reference 19.

- Some assumptions in the operation of the model had to be made due to contradictory statements in three tables in the new specification SS-P0002-510D, Level B Guidance, Navigation, and Control, dated 30 August 1976 The tables in question are

  Table 3-3 = GN&C Sequenced Events, page 3-39 ff, hereafter referred to as reference A

  Table 3-4 = GN&C Time Line, page 3-91 ff, hereafter referred to as reference B

  Table 3-8 = GN&C Execution Rates, page 3-140 ff, hereafter referred to as reference C.

  SDC's interpretation and subsequent assumptions for execution rate changes and initialization and termination for task 19--Ascent UPP and task 206--Ascent Display Processing are as follows·

  a Task 19 (Asc UPP) will be initiated at event 14 in MM101 as stated in ref. A, with an execution rate of 0.5 Hz (ref. C) This is in contradiction with ref. B, which indicates start of task 19 at event 19 in MM102

  b Task 19 will then change its execution rate to 6.25 Hz at event 19 as per ref C, instead of initiation as per ref B.

  c Task 19 will change execution rate from 2 0 Hz to 0.5 Hz at event 32 as per refs. A and C, instead of terminating as indicated in ref. B.

  d. Task 19 will not operate between events 44 and 45 and after event 49 as so indicated by ref. B. This is in contradiction with ref A, which has task 19 operating continually through event 60

  e. Task 206 (Asc Dip) will change execution rate at event 31 from 0 5 Hz to 2.0 Hz as per ref A This is contrary to ref. C, which does not indicate this change in execution rate.

5 1.3 Conceptual Overview of IMSIM

This conceptual overview is presented in order that those not familiar with IMSIM may acquire an understanding of the nature of the data processing system characteristics required for its adaptation and execution

IMSIM is a data system analyzer for modeling a wide range of computer configurations, software workloads, and executive program algorithms It is a tool designed to provide the analysis needed to determine and/or verify the operational capability of the hardware, workload, and executive control elements of a data processing system to meet functional requirements The IMSIM simulator

is a discrete event loading analysis model based on data traffic that flows through static elements It is a large scale computer program compiled in System Development Corporation's MODLIT language which supports production runs and real-time interactive use.

The principal elements of the IMSIM Simulator are described in the subsections that follow.

5 1 3.1 Hardware Representation The equipment simulation categories used in IMSIM cover five basic types of equipment memory units, storage units, computer processors, data transmission links, and a group called "devices" that includes all hardware not covered by the other four categories Although there is no theoretical constraint upon the organization of processors and memory units, attempts by the computing industry to design control programs (operating systems) for various configurations of computers have resulted in the definition of a substructure for large computer systems To realistically represent such systems for simulation, IMSIM includes the concept of the "virtual machine": a computer in which at least one processor can access all memory units. In its simulation runs, SDC has simulated the Space Shuttle's digital data processing system as one Virtual Machine with four GPCs

Storage units and devices are generally considered as global (systemwide) system components, but can be viewed as local (to a virtual machine) when connected exclusively to a machine via data transmission links Processors and memory units are always considered as local components. Data links are defined for use in connecting any components except processors, and have either local or global status, depending upon the configuration.

Inputs to IMSIM include the means for specifying characteristics for individual members of each of the component types mentioned, together with a description of the way in which they are to be configured One other type of component is defined in IMSIM and is classified as hardware the "data set" A data set may be viewed as a subdivision of a storage unit, and is intended to correspond to a file of data to be stored in the unit

5 1 3 2 Software and Workload Representation. In order to study the dynamic behavior of a system representation by IMSIM, it is necessary to apply a workload to the system A workload structure has been incorporated in IMSIM which resembles that of the actual computer system It includes general building blocks for rudimentary representation of computer programs and data and for describing data transmission, and the means of organizing these elements into a hierarchical structure which is consistent with the hardware representation. The building blocks are denoted as routines, data blocks, and messages. These are combined into "tasks" which are units of work to be performed by a single virtual machine

Tasks, in turn, are organized as a time-distributed network of steps which are collectively denoted as a "job", a job is a unit of work to be performed by the overall system. This organization is depicted in figure 5-1.

Routines and data blocks are always considered to be local elements of virtual machines, while messages may have either global or local significance, depending upon their individual characteristics and the hardware configuration Inputs to IMSIM provide the means for specifying characteristics of individual sharability among concurrent tasks

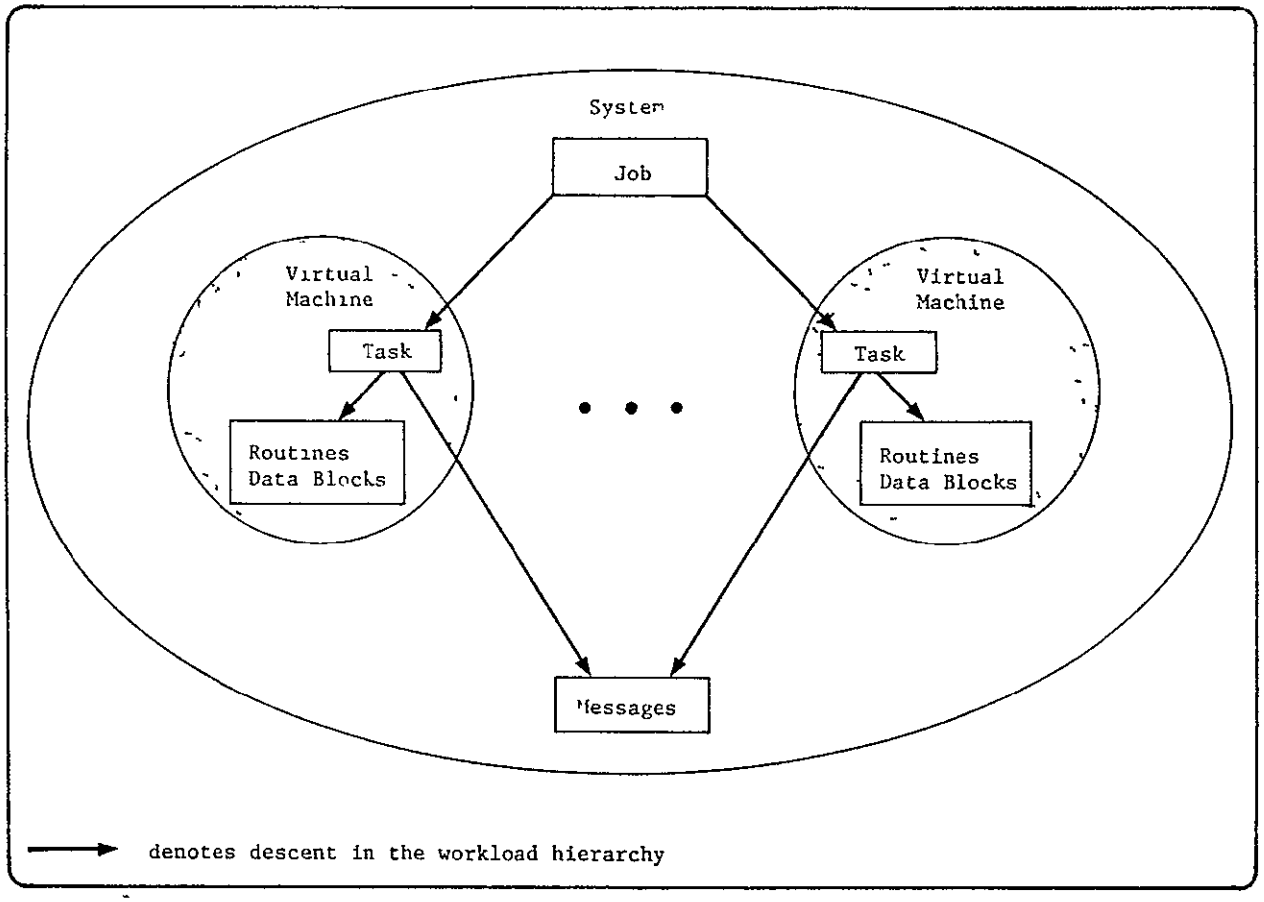

Figure 5-1. Workload Structure in a Simulated System

5 1.3 3 Functional Description. The functional logic which is incorporated in IMSIM includes representation of hardware behavior, applications programs, and executive software Distinguished system components--whether hardware or software--are represented by suitable MODLIT entities such as facilities and storages Both the logic and the system components are generalized IMSIM capabilities which must be tailored to suit the system to be simulated. For this reason, IMSIM is designed to operate in two phases· initialization and simulation In the initialization phase, IMSIM receives and processes "forms" which complete a system definition and describe a workload to be applied to the defined system during simulation Certain system specifications can also be processed during simulation, thereby permitting the dynamic modification of the system.

The logic of IMSIM is expressed in terms of MODLIT logic blocks, and can be subdivided into eight sections

a. Processing of input specifications

b Processing of job requests

c. Task preparation

d Task execution

e. Element space allocation

f Message preparation

g. Message transmission

h Task removal

The first of these eight sections constitutes the initialization phase A portion of this phase, together with the other seven sections, comprise the simulation phase

5 1 3 4 Preparation of Model Specifications This section describes the various specification forms which were used to complete the definition of IMSIM for representation of the Space Shuttle's DDPS and to define software and workload characteristics

Each parametric input form is represented by one or more lines of input. All input lines are interpreted on a free-field basis, i e , one or more spaces separate successive fields Only the first 71 characters of each line are interpreted Positions 1 through 70 contain the information to be read, position 71, if occupied by any character other than a zero, indicates that the next line

in the input sequence is a continuation of the current line Positions 72 through 80 are used for sequence numbers.

A double prime (' ') in positions 1 and 2 or a quotation mark (") in position 1 indicates that the line is a comment which is used solely to annotate printed outputs.

The first field of each form contains an integer which identifies the form type. The layout line which follows the column headings line of each form description indicates the magnitude of values for each field (e.g , nnnnnn) and signifies the optional use of a fractional value nnn. means a fractional value is possible, while nnn means that only integer values should appear The column headings X44, X45, X56, and X57 represent Saves cells† which correspond to storage locations within MODLIT. The parameters X44, X45, X56, and X57 will be assigned the values appearing under these headings for use in a MODLIT variable. The MODLIT variable, specified under the column heading V is then computed as a function of the values in the Savex cells.

The 14 input forms that follow depict the formats necessary for input to IMSIM Forms 1 through 5 are used to described the simulated workload characteristics, while the remaining 9 forms are used to describe the hardware configuration.

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†Savex cells are specially designated MODLIT data base entries used for a variety of computation and control purposes

a FORM 1 - JOB DEFINITION

Form	Job	Task Type	Priority	Nature	Go/NoGo	Immediate Predecessors
1	nn	nn	n	n	nnn	nn nn .. (to a maximum of 24)
E.G.						
1	2	6	1	1	1	
1	2	15	3	1	1	
1	2	8	1	1	1	6 15
1	3	6	2	1	377	

Job — The number of the job prototype being defined (Job 1 is reserved for the simulated executive)

Task Type — Each line specifies a job step - this field contains the number of the type of task for the step (see Form 2) No more than 24 steps can be specified per job

Priority — A number between 0 and 49 indicating the priority of the step, 49 is the highest priority.

Nature — A 3 in this field for any job step indicates that the job is cyclic (i.e , it repeats continuously), if the job is not cyclic, a 2 indicates that the step is cyclic, otherwise, a 1 should appear

Go/NoGo — The number of a MODLIT variable whose value determines whether of not the step is to be performed.

<0 skip the job step
=0 hold the job step
>0 do the job step

The variable is evaluated after the required routines and data blocks have been loaded, if Nature is 2, it is also evaluated whenever the step is ready to recycle As a special case, the Go/NoGo field may be specified as 0, this imples that "Go" is to be indicated whenever X577 contains the task number of the step, and that computation time functions are to be evaluated at the same instant

Immediate Predecessors — The numbers of other tasks in the job which must directly precede the given step during performance, and which must complete before the given step can start, there may be no predecessors.

b FORM 2 - TASK DEFINITION

Form	Task Type	Service Class	Permissible Delay	Required Elements
2	nn	n	nnnnnnnnnn	nnnnn nnnnn (to a maximum of 100)
E G				
2	6	5	0	30007 30021 40055 40030 50020 50008
2	15	1	100	30008 40030 50010 50011

Task Type — The number of the task prototype being defined (Tasks 1 through 5 are reserved for the simulated executive)

Service Class
1 - critical, perform immediately (Permissible Delay is ignored)
2 - timely, becomes critical following lapse of Permissible Delay
3 - timely, becomes noncritical following lapse of Permissible Delay
4 - timely, discard if Permissible Delay elapses
5 - noncritical (Permissible Delay is ignored)

Permissible Delay — A period in milliseconds commencing with job start (see Service Classes 2 - 4)

Required Elements — Identifiers of routines (see Form 3), data blocks (see Form 4), and messages (see Form 5) which comprise the task, identifiers are
300nn for a routine type nn
400nn for a data block type nn
500nn for a message type nn

c FORM 3 - ROUTINE DEFINITION

Form	Routine	Share Class	Library Data Set	Size	Execution Time	Processor Class	Memory Residence	Computation Time		
								V	X44	X45
3	nnn	n	nnnnnn	nnnnnnnn	nnnnnnnn.	nn	nnnnn	nnn	nn	nn
E G										
3	7	1	110001	12000	600	1	70001	16	20	
3	21	0	366	3200	0	10	371	380		

Routine — The number of the routine type being defined (Routine 1 is reserved for the simulated executive)

Share Class — 1 if the routine can be shared among tasks, 0 if not

Library Data Set — The identifier of the data set which is supposed to contain a loadable form of the routine (See Form 11), or the number of a MODLIT variable which is to be evaluated when loading occurs, to determine the identifier

Size — The number of characters of memory space required for the routine

Execution Time — The maximum amount of time (in milliseconds) that the routine will operate for a task, zero if no limit

Processor Class — The level of processor capability required to execute the routine (See Form 9)

Memory Residence — The memory into which copies of the routine can be loaded, or zero if no restriction,

- 0 - load into any memory, as required for tasks
- nnn - evaluate variable nnn to determine memory identifier
- 700nn - the memory to which the routine is to be loaded

Computation Time — The number of a MODLIT variable to be evaluated whenever a transmission completes for a task, to determine the amount of computing (in milliseconds) to be spent in executing the routine, also, the values assigned to X44 and X45 for possible use as parameters in the given variable (they may be ignored)

d FORM 5 - MESSAGE DEFINITION

Form	Message	Nature	Source	Sink	Length			Interval			Start Time	Total	Storage Effect	Trigger Domain
					V	X44	X45	V	X44	X45				
5	nnn	n	nnnnnn	nnnnnn	nnn	nn	nn	nnn	nn	nn	nnnnnnn	nnnnn	n	n
E G														
5	8	0	60003	40030	16	20	0	16	0	0	0	1	0	0
5	20	1	50050	110002	388	200	15	16	70	0	0	0	1	0
5	31	0	397	398	399	0	0	16	20	0	100	0	0	1

Message — The number of the message type being defined (Messages 1 through 5 are reserved for the simulated executive)

Nature — 0 - frequency of transmission (see the Interval field) is dependent upon task execution, a separate transmission sequence is established for each task
1 - message transmission is shared among tasks and occurs independently of task execution, but transmissions may accumulate
2 - message transmission is shared among tasks and occurs independently of task execution, but if a transmission is not started prior to the next transmission due for the message, the transmission is lost

Source
Sink — The identifier of a defined unit which is suitable for use as a source or sink, or the number of a MODLIT variable to be evaluated whenever the messsage is to be transmitted, to determine the identifier

nnn - variable number
40nnn - data block (see Form 4)
50nnn - message (used only as a source)
60nnn - device (See Form 6)
70nnn - memory (See Form 7)
110nnn - data set (See Form 11)

Length — The number of a MODLIT variable to be evaluated whenever the message is to be transmitted, to determine the length (in characters) of the transmission, also, the values assigned to X44 and X45 for possible use as parameters in the given variable (they may be ignored)

Interval — The number of a MODLIT variable to be evaluated whenever a transmission of the message (or triggering message if appropriate) completes, to determine a time interval (in milliseconds) If Source is a message, this is the time between completion of the triggering message and the start of the response, if the Source is not a message, this is the time between successive transmissions of this message X44 and X45 are used as in the Length field, the Interval field is ignored if Total is 1 for a nontriggered message

Start Time — The period (in milliseconds) which must elapse before the message can be transmitted, measured from the start of a task if Nature is 0, or else from the start of the job

Total — The number of transmissions of the message, 0 if no limit

Storage Effect — 1 if transmissions is to change the size of a source or sink data set by the length of the message, 0 if no effect is wanted

Trigger Domain — Applies only to messages triggered by other messages, 0 if any transmission of the trigger message is to trigger this message, 1 if only transmissions related to the task are relevant to this message

e FORM 6 - DEVICE DESCRIPTION

Form	Device	A/D	Share Class	Record Size	Transmission Rate		Reset Period
					Input	Output	
6	nnn	n	n	nnnnnn	nnnnn	nnnnn	nnnnn
E G							
6	1	1	0	0	10	10	3
6	12	1	1	800	5	6	1

Device — The number of the device being described

A/D — 1 - digital
2 - analog
3 - digital to analog
4 - analog to digital

Share Class — 0 - can only be assigned to one task at a time
1 - can be shared among tasks

Record Size — Limits the length of a transmission by truncating it, if necessary, to the number of characters indicated, zero if no limit on record size

Transmission Rate — The rate (in characters/millisecond) at which data can be received (Input) or sent (Output) by the device

Reset Period — The time (in milliseconds) required by the device to recover from a transmission before it can start another

f. FORM 7 - MEMORY UNIT DESCRIPTION

Form	Memory Unit	Speed Factor	Number of Pages
7	nnn	nnnn	nnnnn
E G			
7	1	1	256
7	2	0 25	1000

Memory Unit — The number of the memory unit being described

Speed Factor — The ratio of the memory access rate to a nominal rate of 1 character per microsecond, e g , "2 5" indicates an access rate of 2 5 characters/microsecond

Number of Pages — The number of virtual machine pages (see Form 14) which constitute the capacity of the memory unit

9. FORM 8 - STORAGE UNIT DESCRIPTION

Form	Storage Unit	A/D	Share Class	Cycle	Transmission Rate	Capacity	Access Period					
							V	X44	X45	X56	X57	
8	nn	n	n	nnn	nnnnn	nnnnnnnn	nnn	nn	nn	nn	nn	
E G												
8	1	1	1	0	8 2	1000000	16	5				
8	2	1	0	25	12 1	500000	388	20	5			

Storage Unit — The number of the storage unit being described

A/D — 1 - digital
2 - analog

Share Class — 0 - can only be assigned to one task at a time
1 - can be shared among tasks

Cycle — A zero indicates that the storage unit is noncyclic, i e , it is in motion only during transmission operations (e g , a tape) A nonzero value indicates that the storage unit is cyclic (e g , a disk or drum) with a period in milliseconds as specified by the value

Transmission Rate — The rate (in characters/millisecond) at which the storage unit can send or receive data

Capacity — The number of characters which the storage unit can accommodate

Access Period — The number of a MODLIT variable to be evaluated whenever the storage unit is to be accessed, to determine the time (in milliseconds) that is to be spent in locating the data (or place for the data) to be transmitted, also, the values assigned to X44, X45, X56, and X57 for possible use as parameters in the given variable (they may be ignored) Note that X44 must be in milliseconds if Cycle is 0

h FORM 9 - PROCESSOR DESCRIPTION

Form	Processor Unit	Speed Factor	Class	Interrupts	Task Switch Period	Virtual Machine	Connected Memory Units
9	nn	nnnn	nn	n	nnnnn	n	nn nn (to a maximum of 20)
E G							
9	1	1 5	10	5	2	1	1 2 5
9	2	0 9	11	0	4	1	1

Processor Unit — The number of the processor being described

Speed Factor — The ratio of the processor operating speed to a nominal rate of 1 instruction per microsecond, e g , "1 5" indicates a processing rate of 1500000 instructions per second

Class — A number used to match routines (see Form 3) with appropriate processors, classes 1 through 9 have related capabilities such that 1 is a subset of 2, 2 is a subset of 3, etc There are no implied capability relations concerning classes 10, 11, etc

Interrupts — A number which indicates the types of interrupts to which the processor can respond
0 - none
1 - I/O
4 - job and task initiation requests
5 - all

Task Switch Period — The time (in milliseconds) required for the processor to drop one task and commence another, as a consequence of an interruption

Virtual Machine — The number of the virtual machine (see Form 14) to which the processor belongs

Connected Memory Units — The numbers of memory units (see Form 7) which are addressable by the processor, all of the memory units must belong to the same virtual machine as the processor

FORM 10 - DATA LINK DESCRIPTION

Form	Data Link	Mode	Transmission Rate	Time Lag
10	nnn	n	nnnnn	nnnn
E G				
10	5	0	10	0
10	306	1	2	0

Data Link — If less than 100, this field contains the number of a half-duplex communication channel If greater than 100, it signifies a multiplexed set of half-duplex subchannels, the set number is given by the 100's digit, and the number of subchannels in the set is given by the last two digits (e g , "230" would define a multiplexed channel number 2, consisting of 30 subchannels)

Mode — Applies only to multiplexed data links
- 0 - the subchannels are completely independent of each other
- 1 - the channel will operate in "burst mode" if any of its subchannels is subjected to a load in excess of the specified transmission rate This will cause interruption of any other transmissions in progress on the data link, and may result in data loss

Transmission Rate — The maximum rate (in characters/millisecond) at which the link operates, in the case of a multiplexed channel, it is the rate for each subchannel

Time Lag — The period (in milliseconds) between sending and receiving one unit of data

J FORM 11 - DATA SET DEFINITION

Form	Data Set	Storage	Organization	Initial Size	Maximum Size
11	nn	nn	n	nnnnnnnnnn	nnnnnnnnnnnn
E G					
11	1	3	0	0	1000000
11	66	12	1	10000	5000000

Data Set — The number of the data set being defined

Storage — The number of the storage unit (see Form 8) on which the data set resides

Organization — 0 - the data set is serially addressed
1 - the data set is randomly addressed

Initial Size — The number of characters in the data set when simulation commences

Maximum Size — The maximum space (in characters) reserved for the data set on the specified storage unit

k FORM 12 - CONFIGURATION SPECIFICATIONS

Form	Unit	Data Link Connections
12	nnnnn	nnn nnn nnn (to a maximum of 96)
E G		
12	60002	1 23 73 202 203
12	70011	200 300
12	80006	5 6 7 8 9

Unit — A 5-digit identifier of a memory unit (see Form 7), a storage unit (see Form 8), or a device (see Form 6) which is to be connected to specified data links (e g , 60002 specifies device 2)

Data Link Connection — The numbers of data links (see Form 11) to which the given unit can be connected for message transmission Independent channels are represented by their respective numbers A particular subchannel of a multiplexed channel is represented by specifying the set number of the channel as the 100's digit, and the ordinal number of the subchannel in the set as the last two digits (e g , 209 for the ninth subchannel of set 2), all subchannels of a multiplexed channel are represented by the set number as the 100's digit and 00 for the last two digits

Any units which do not share some data link can be assumed to share an implicit link for the purpose of message transmission (see Form 13, Algorithm 4B)

1 FORM 13 - ALGORITHM SELECTION

Form	Algorithm														
	1A	1B	2A	2B	2C	2D	2E	3A	3B	3C	4A	4B	5A	5B	6A
C G 13	0	0	1	1	0	0	1	1	0	1	0	0	1	1	1

Algorithm 1 Transmission Path Selection
- A = 0 If all suitable links are in use, choose the first one and wait
- A = 1 If all suitable links are in use, wait until one becomes available
- B = 0 Choose the first suitable link which is not in use, if all are in use, see Algorithm 1A
- B = 1 Choose the first suitable link whether or not it is in use

Algorithm 2 Memory Allocation
- A = 0 Element (i e , routine and data block) confiscation is not permitted
- A = 1 If critical tasks are being considered (See Algorithm 3B), they may confiscate elements or space
- B = 0 Consolidate space whenever an element is no longer needed
- B = 1 Consolidate space only when required for loading additional elements
- C = 0 Elements may coreside in pages
- C = 1 Each element must start on a new page
- D = 0 Inhibit space consolidation
- D = 1 Permit space consolidation
- F = 0 Consolidate space only to meet a requirement
- F = 1 Consolidate space in total for a virtual machine whenever a requirement cannot be met for element loading

Algorithm 3 Task Scheduling
- A = 0 Processing is not interruptible
- A = 1 Processing is interruptible by the executive and critical tasks
- B = 0 Task criticality is not considered, i e , all tasks are treated as noncritical
- B = 1 Critical tasks have precedence and confiscation privileges over non-critical tasks in obtaining processors if interruptions are permitted (See Algorithm 3A)
- C = 0 Scheduling is on a cyclic basis, i e , tasks are placed in time-ordered queues for execution
- C = 1 Scheduling is by task priority

Algorithm 4 Unit Selection
- A = 0 No special treatment for critical tasks
- A = 1 If critical tasks are being considered (See Algorithm 3B), they may confiscate nonsharable devices and storage units
- B = 0 Choose a virtual machine for a task without regard to explicit data link connections, i e , implicit links are to be assumed
- B = 1 Select a virtual machine for each task which permits all messages associated with the task to be transmitted over explicit data links, i e , implicit links are not allowed

Algorithm 5 Element Loading
- A = 0 Do not use a processor to perform loading service
- A = 1 Use a processor for loading elements
- B = 0 Place elements in memory without transmitting loading messages.
- B = 1 Load elements by transmitting from library data sets to memory

Algorithm 6 I/O Service
- A = 0 Do not use a processor for I/O initiation or I/O interrupt response
- A = 1 Use a processor to initiate I/O and to respond to I/O interrupts

FORM 14 - VIRTUAL MACHINE DEFINITION

Form	Virtual Machine	Executive Memory Unit	Virtual Memory		
			Size	Page Size	
14	n	nn	nnnnnnnnn	nnnnnnnnn	
E G 14 14	1 2	1 11	100000 120000	1000 500	

Virtual Machine — A number between 1 and 6, indicating the virtual machine being defined

Executive Memory Unit — The number of the memory unit (see Form 7) in which the simulated executive for the virtual machine (i e , routine 30001 and data block 40001) will reside It must be a memory which is connected to a class 10 processor (ee Form 9) for the machine, since that is required for execution of the executive

Virtual Memory — Size is the total number of addressable characters in the composite of memory units for the virtual machine Page Size is the number of characters per addressable page of memory

5.1.3.5 Preparation of a Job Schedule and Event Occurrences. The Job Schedule provides the means to initiate jobs, add job and task definitions, modify or add system specifications, and specify events through setting of Savex cells. Job start times are specified which trigger the commencement of selected jobs. As each job is initiated, tasks and message transactions are generated and executed, resources are scanned for availability Specific events which are to occur within jobs are defined as event times for the setting and modification of Savex cells. The Job Schedule is read during the simulation phase, and job schedule forms should be ordered on the time field. No job or event should be scheduled to start before simulated time 20, since a line which begins with a number less than 20 is treated as a specification form. The executive (job 1) is automatically started and needs no job initiation in the schedule. In subsequent runs, the input schedule may be varied to study the effects of different job execution sequences while keeping the basic hardware and prototype software configurations fixed.

The two forms that follow depict the formats necessary for job initiation and event occurrence

a JOB INITIATION

Time	Job	Trigger Message	Repeat Flag
nnnnn	nn	nn	n
E G			
150	2		
160	3	28	0
210	6	12	1

Time — The time (in milliseconds) at which the job is to introduced to the system

Job — The number of the job (see Form 1) to be initiated

Trigger Message — If this field is specified, it must contain the number of a message (see Form 5) which must complete transmission after the given time, in order to start the job If unspecified, the job will be started immediately

Repeat Flag — Applicable only if a trigger message is specified
- 0 - the job is initiated once, following the next completion of the transmission of the specified message
- 1 - the job is to be initiated following every occurrence of the specified message transmission

b EVENT OCCURENCE

Time	0	Events		- - - - -	Event K	
		Savex	Increment		Savex	Increment
nnnnn	0	nnnn	nnn		nnnn	nnn
E G						
1800	0	688	+2			
1950	0	680	1		681	10
1960	0	688	-1		681	1

Time The time (in milliseconds) at which the indicated events occur It must be greater than 19

Savex The number of the Savex cell associated with the event

Increment The amount by which the Savex cell is to be changed

5.1 4 Overall Approach

In coordination with NASA a simulation model version was developed for the Space Shuttle, reflecting the hardware characteristics and the functions to be performed during the Ascent phase (OPS 1) of the Orbital Flight Test for the Space Shuttle Orbiter.

The parameters for the hardware, that were contained in the ALT simulation test (see reference 4) and were the same for the Orbital Flight Test, were used in the OFT simulation. The parameters for the additional hardware that has been used in OFT were extracted as follows:

a. For the Master Events Controller (MEC) from references 15 and 21

b For the Engine Interface Unit (EIU) from references 12 and 15.

These parameters are discussed in detail in section 5.2.3.

Characteristics relating to the expected performance of software programs, modules, and cyclic executives have been based largely on the Principal Functions, as described in detail in the FSSR documents for Level C, Guidance, Navigation, and Control in the OFT for the Space Shuttle, and the OFT Function Level Requirements for GN&C in the Computer Program Development Specification Volume V, Book I, SS-P-002-510D. Approximation of total number and type of instructions for each routine for each Principal Function were determined Refined timing of the execution phase of each routine was derived by determining the execution time for each set of instructions that operate under certain specified conditions, based on the instruction execution times given in references 26 through 28 and reference 30, and execution times given in reference 27--both in appendix D (table D-2), parts 1 and 3 of volume 2.

5 1 4 1 Approach to Hardware Definition. The simulated configuration is based on the OFT configuration of the Space Shuttle Orbiter It consists of the following with the number in parentheses indicating the entity ident number on the IMSIM input specification forms

Certain entities are simulated separately as their characteristics and functions are distinct and logically different even though they are physically constructed as a unit, e g., the GPCs are logically depicted as consisting of a CPU, a Core Memory, and an IOP.

a. Four Space Shuttle Advanced System/4Pi Model AP-101 Central Processing Units (90001, 90002, 90003, 90004). Only one processor will be active at any one time (90001), the other processors being in the redundant mode The fifth Central Processing Unit has not been simulated during this loading analysis.

(Page 5-30 blank)

b Four GPC/IOP combined Main Memories, containing 109K words each being 436K bytes each (70001, 70002, 70003, 70004). The fifth Memory has not been simulated during this loading analysis

c. Four IOPs with 24 channels each. The fifth IOP has not been simulated during this loading analysis

d. Two Mass Memory tapes, each with a capacity of 134 X 10^6 bits (17,000,000 characters) (80001, 80002) -- (not used during this simulation).

e Three Display Electronic units (DEUs) (60001, 60002, 60003).

f Three Display units (DUs) (60005, 60006, 60007).

g Two Keyboard Entry units (KBs) (60027, 60028).

h. Eight Multiplexer/Demultiplexer units (MDMs) for flight critical functions (60009, 60010, 60011, 60012, 60013, 60014, 60015, 60016).

i Three Display Driver units (DDUs) (60017, 60018, 60019)

j Two Pulse Code Modulator Master units (PCMMUs) (60095, 60096).

k Three Engine Interface Units (EIUs) (70011, 70012, 70013)

l Four MDMs for Solid Rocket Booster launch (60030, 60031, 60032, 60033)

m Two MDMs for Ground Interface launch (60034, 60035).

n Two MDMs for Payload (60036, 60037)

o Two Master Events Controllers (MECs) (70014, 70015)

p Twenty-seven data link buses grouped by function (100001 through 100027).

q Seven half-duplex data links for interdevice communications (100029 through 100036)

Each of the above items is described in detail in section 5.2.3 2

A diagram of the simulated configuration for OFT is given in figure 5-2 and depicts the hook-up of these elements.

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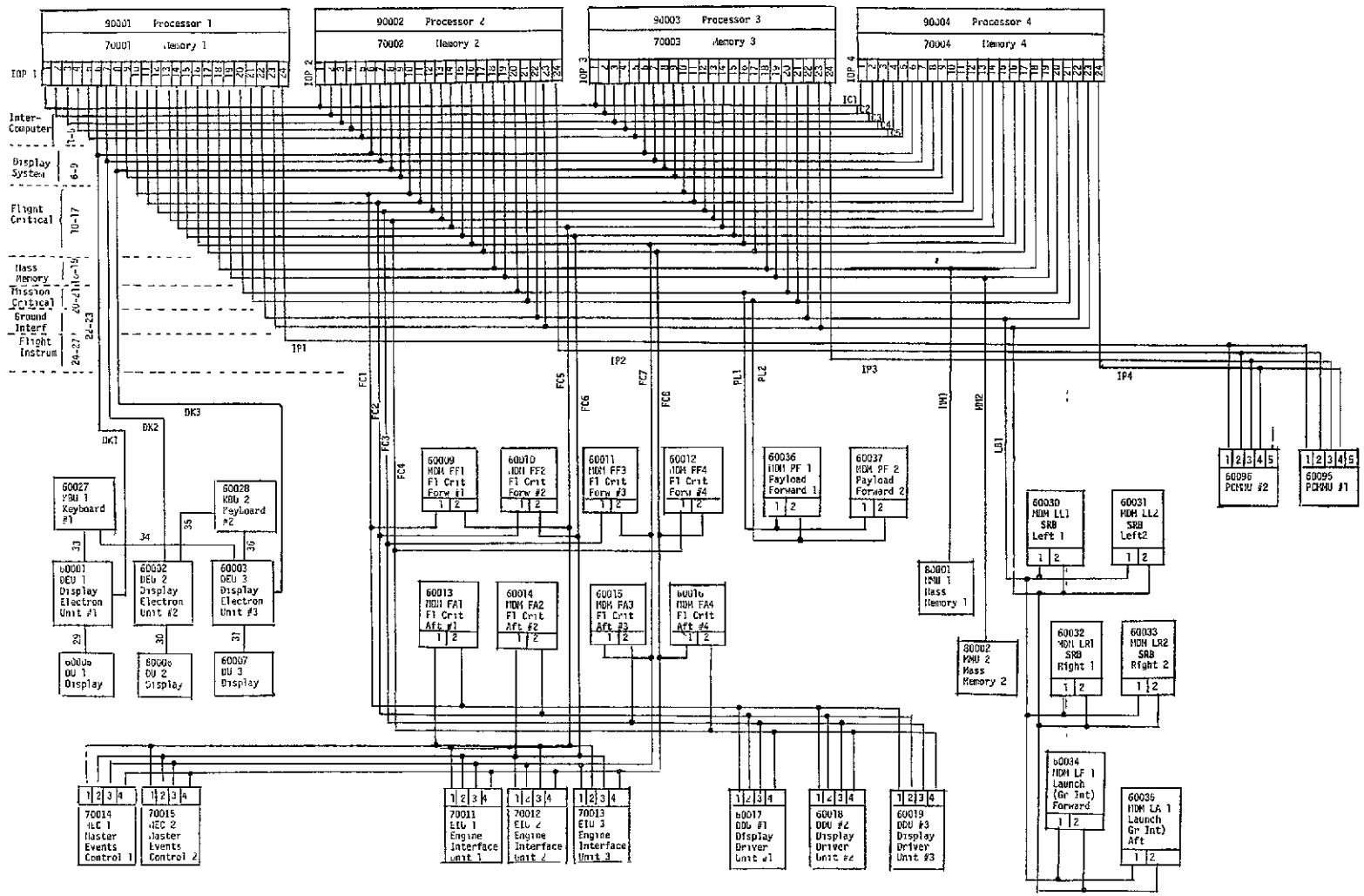

Figuration 5-2. IMSIM Simulated OFT Configuration

FOLDOUT FRAME

FOLDOUT FRAME 2

5.1 4 2 Approach to Workload Definition The software requirements for the Space Shuttle Orbiter onboard digital data processing system specify a hierarchical system to be developed according to established techniques of structured programming The activity within an individual computer (GPC) of the DDPS essentially consists of a set of tasks which may be performed concurrently (i.e., multitasking) and which compete with each other for use of the central processor. The tasks are assigned unique priorities to be used in resolving conflicts over the CPU, and they are scheduled either by time pulses or by the occurrence of specific events All input/output control is handled by IOPs, thereby relieving the CPU of these specialized functions

Definition of an IMSIM workload to represent this activity necessitated

a establishment of specific objectives for simulation,

b an understanding of the organization and intercommunication of the software,

c information and assumptions concerning the amount of computing and data transmission performed as a function of the state of the system,

d value judgments as to relative significance of functions, events, states, etc , to the simulation objectives, and

e methods to be used for representation of each of the significant aspects of the system

These five areas of concern are interdependent and had to be treated in parallel, for example, it is impractical to gather detailed information and make assumptions about a software module which is essentially irrelevant to simulation goals. Simulation objectives were tentatively established and are presented in sections 5 1.1 and 5 1 2 The methods for software representation are described in section 5.2 3.3 Since virtually all of the activity within the DDPS is organized into schedulable "processes", these processes are identified, together with the conditions for activating them, and the program modules which are executed for them The processes are associated with three areas. User Interface, System Control, and Guidance Navigation and Control

For convenience, a table containing all the Principal Functions in the ascent phase with the corresponding task numbers and four-letter task abbreviations used during this study is given in table 5-1

Table 5-1 Principal Functions/Tasks in Ascent Phase by Function Number

FUNCTION NUMBER	FUNCTION NAME	TASK ABBREV	TASK NUMBER
1	Ascent First Stage Guidance	ST1G	6
2	Ascent Second Stage Guidance	ST2G	7
3	Orbit Insertion Guidance	OING	8
15	Ascent Navigation	ASNV	15
19	Ascent User Parameter Processing	AUPP	19
36	Aerojet Digital Autopilot	ADAP	36
38	IMU Inertial Processing	IMUP	309/319
40	Orbiter Rate Gyro Subsystem Operating Program	ORGP	40
41	Solid Rocket Booster Rate Gyro SOP	SRGP	41
42	Accelerometer Assembly SOP	AASP	42
45	Radar Altimeter SOP	RASP	45
49	Body Flap Position Feedback SOP	BFFP	49
50	Aerosurface Actuator CMD SOP	AEAP	50
52	Hydraulic System SOP	HYSP	52
54	Translation Hand Controller SOP	THCP	54
60	Main Propulsion Sys Thrust Vector CNTL CMD SOP	MTVP	60
62	SRB Thrust Vector Control Command SOP	STVP	62
64	OMS Thrust Vector Control Command SOP	OTVP	64
65	OMS Thrust Vector Control Feedback SOP	OTFP	65
70	Main Propulsion System Dump Sequencer	MPSD	70
71	Selection Filtering	SFIL	71
72	Inertial Measurement Unit Redundancy Management	IMRM	72

Table 5-1 (cont)

FUNCTION NUMBER	FUNCTION NAME	TASK ABBREV	TASK NUMBER
91	RCS Fault Detection and Identification	RCSF	91
92	OMS Fault Detection and Identification	OMSF	92
95	Body Flap CMD Fault Detection, Identification	BFFD	95
97	Attitude Processing	ATTP	97
101	Orbiter Maneuvering System Quantity Monitor	OMQM	101
102	Reaction Control System Quantity Monitor	RCQM	102
110	Guidance, Nav & Control Annunciation Interface	GAXI	110
114	Redundant Set Launch Sequence Processing	RSLS	114
115	Solid Rocket Booster Separation Sequence	SRSS	115
116	External Tank Separation Sequencer	ETSS	116
119	Space Shuttle Main Engine Monitor Function	SMEM	119
120	Solid Rocket Booster Monitor Function	SRBM	120
139	Ascent Navigation Sequencer	ASNS	Rt 13
161	Vent Door Control Sequencer	VNTS	161
164	Range Safety Function	RNGS	164
165	Space Shuttle Main Engine Operations	MOPS	165
168	Ascent Attitude Director Indicator Proc	ASAI	168
171	Three-Axis Rotational Hand Controller SOP	RHCP	171
175	Guidance/Control Steering Interface	GCSI	175
176	Ascent Digital Autopilot	ASDP	176
180	Guidance, Navigation & Control Switch Proc	GSWP	180
181	Space Shuttle Main Engine SOP	SMEP	181

Table 5-1 (cont)

FUNCTION NUMBER	FUNCTION NAME	TASK ABBREV	TASK NUMBER
182	Orbiter Maneuvering System Firing Sequencer	OMFS	182
183	OMS-to-OMS Interconnect Function	OMIC	183
187	Orbiter Actuator Slew Check	OASC	-
188	Solid Rocket Booster Actuator Slew Check	SRSC	188
190	Ascent Reaction Control System CMD SOP	ARCP	190
193	Elevon Delta Pressure Feedback SOP	EDFP	193
197	Ascent User Parameter Proc Sequencer	AUPS	197
201	Insertion Digital Autopilot	IDAP	201
203	Solid Rocket Booster Data Acquisition	SRDA	203
206	Ascent Display Processing	ADIP	206
210	Ascent Maneuver Display Proc	AMDP	210
-	Fast Cycle Executive	GEFC	306
-	System Software Interface Processor	SSIP	307
-	Minor Cycle Executive	GMIN	309
-	IMU Major Cycle Executive	IMMC	319
-	MCDS Input Processor	MCDS	332
-	LDB I/O Processor	LDBP	333
-	User Interface	USIF	334
-	Cyclic Display Processor	CDIP	335
-	GPC Switch Monitor	GPSW	337

5 1 4.2 1 User Interface Processes. Four User Interfaces processes were selected for representation. They are identified by the principal modules as follows:

- DCI_CYC_DISPLAY - Cyclic Display Processing
  Scheduled for execution at 100 ms intervals

  Other modules called include.
  DCI#FMT - Data Formatting
  DCI#CON - Data Conversion

- DGI_LDM_IO - Launch Data Bus I/O Processor
  Scheduled to execute at 40 ms intervals.

  Other modules called include·
  DLM_LDB_ROUT - LDB Message Router
  DMM_MCDS_PROCESS - MCDS Message Processor

- DMC_SUPER - User Interface Control Supervisor
  Performed whenever events indicate MDCS or ICC messages, or an applications service request, or completion of MM I/O service.

  Other modules called include
  DMC_FUNCTIONS - Keyboard Functions
  DMC_SEQ_REQ_PROC - Sequence Request Processing
  DMC_APP_INT - Application Control Interface
  DMC_MCDS_CNT - MCDS Display Control
  DMC_NEW_DISPLAY - New Display Processing
  DMC_APP_KEY_PROCESS - Application Keys Processing
  DIM_ICC_COLLECTOR - ICC Message Collector
  DMC_DISPLAY - Display Coordination

- DMI_MCDS_IN - MCDS Input Processor
  Scheduled to execute at 200 ms intervals.

  Other modules called include·
  DMM_MCDS_PROCESS - MCDS Message Processor

5.1.4.2.2 System Control Processes Two System Control processes were selected for representation They are identified by their principal modules as follows

- AIE_SIP - System Software Interface Processor
  Scheduled to execute at 40 ms intervals on all GPCs for synchronization and ICC

  Other modules called include
  DCD_DOWNLIST - GPC Downlist Formatter
  DIM_ICC_COLLECTOR - ICC Message Collector
  DME_ICC_ROUT - ICC Message Router
  DMS_FMS - Fault Message Scan

- ARA_GPC_SWITCH - GPC Switch Monitor
  Scheduled to execute at 1000 ms intervals to monitor switches and adjust system state

5 1.4.2.3 Guidance, Navigation, and Control Processes Fifty-five GN&C functions are indicated as relevant to the Ascent phase of OFT--Events 1 to 50--and are represented in the OFT model. They are cyclicly scheduled as specified in reference 19 The numbers in parentheses indicate the paragraph numbers in the Level B - GN&C CPDS (reference 19). The GN&C functions are as follows.

- AS_1STG_GUID - Ascent First Stage Guidance (4.1)
- AS_2STG_GUID - Ascent Second Stage Guidance (4 2)
- ORB_INS_GUID - Orbit Insertion Guidance (4.3)
- ASC_NAV - Ascent Navigation (4.15)
- ASCENT_UPP - Ascent User Parameter Processing (4 19)
- AERO_JET_DAP - Aerojet Digital Autopilot (4.36)
- IMU-INT_PROC - Inertial Measurement Unit Inertial Processing (4.38)
- ORB_RG_SOP - Orbiter Rate Gyro Subsystem Operating Program (4 40)
- SRB_RG_SOP - Solid Rocket Booster Rate Syro Subsystem Operating Program (4.4.1)
- AA_SOP - Accelerometer Assembly Subsystem Operating Program (4 42)
- RA_SOP - Radar Altimeter Subsystem Operating Program(4 45)
- BF_PFB_SOP - Body Flap Position Feedback Subsystem Operating Program (4 49)
- AERO_ACT_SOP - Aerosurface Actuator Command Subsystem Operating Program (4.50)
- HYD_SYS_SOP - Hydraulic System Subsystem Operating Program (4.52)
- THC_SOP - Translational Hand Controller Subsystem Operating Program (4 54)
- MPS_TVC_CMD_SOP - Main Propulsion System Thrust Vector Control Command Subsystem Operating Program (4.60)
- SRB_TVC_CMD_SOP - Solid Rocket Booster Thrust Vector Control Command Subsystem Operating Program (4.62)
- OMS_TVC_CMD_SOP - Orbital Maneuvering System Thrust Vector Control Command Subsystem Operating Program (4.64)
- OMS_TVC_FB_SOP - Orbital Maneuvering System Thrust Vector Control Feedback Subsystem Operating Program (4.65)
- MPS_DUMP - Main Propulsion System Dump Sequencer (4.70)
- SF - Selection Filtering (4 71)
- IMU_RM - Inertial Measurement Unit Redundancy Management (4.72)
- RCS_FDI - Reaction Control System Fault Detection and Isolation (4 91)
- OMS_FDI - Orbital Maneuvering System Fault Detection and Isolation (4.92)
- BF_CMD_FDIR - Body Flap Command Fault Detection, Identification, and Reconfiguration (4.95)
- ATT_PROC - Attitude Processing (4.97)
- OMS_QTY_MON - Orbital Maneuvering System Quantity Monitor (4.101)
- RCS_QTY_MON - Reaction Control System Quantity Monitor (4.102)
- GAX - Guidance, Navigation, and Control/Annunciation Interface (4.110)

- R/S_LCH_SEQ - Redundant Set Launch Sequence Processing (4.114)
- SRB_SEP_SEQ - Solid Rocket Booster Separation Sequencer (4.115)
- ET_SEP_SEQ - External Tank Separation Sequencer (4.116)
- SSME_MON_FCN - Space Shuttle Main Engine Monitor Function (4.119)
- SRB_MON_FCN - Solid Rocket Booster Monitor Function (4.120)
- AS_NAV_SEQ - Ascent Navigation Sequencer (4.139)
- VENT_CNTL_SEQ - Vent Door Control Sequencer (4.161)
- RNG_SAFETY - Range Safety Function (4.164)
- SSME_OPS - Space Shuttle Main Engine Operations (4.165)
- ASC_ADI_PROC - Ascent Attitude Director Indicator Processing (4.168)
- 3-AX_RHC_SOP - Three-Axis Rotational Hand Controller Subsystem Operating Program (4.171)
- G/C_STEER - Guidance/Control Steering Interface (4.175)
- ASC_DAP - Ascent Digital Autopilot (4.176)
- GN&C_SW_PROC - Guidance, Navigation, and Control Switch Processing (4.180)
- SSME_SOP - Space Shuttle Main Engine Subsystem Operating Program (4.181)
- OMS_FIRE_SEQ - Orbital Maneuvering System Firing Sequence (4.182)
- OMS/OMS_CONN - Orbital Maneuvering System-to-Orbital Maneuvering System Interconnect Function (4.183)
- ORB_ACT_SLEW - Orbiter Actuator Slew Check (4.187)
- SRB_SLEW - Solid Rocket Booster Actuator Slew Check (4.188)
- AS_RCS_CMD_SOP - Ascent Reaction Control System Command Subsystem Operating Program (4.190)
- DELTA_P_F/B_SOP - Elevon Delta Pressure Feedback Subsystem Operating Program (4.193)
- ASC_UPP_SEQ - Ascent/User Parameter Processing Sequencer (4.197)
- INS_DAP - Insertion Digital Autopilot (4.201)
- SRB_DATA_ACQ - Solid Rocket Booster Data Acquisition (4.203)
- ASC_DIP - Ascent Display Processing (4.206)
- ASC_MNVR_DIP - Ascent XXXXX Maneuver YYYYY Display Processing (4.210)

In addition, three "cyclic executives" employed in the ALT configuration are assumed to have counterparts in the OFT

- GEF_FC_EXEC - Fast Cycle Executive
  Scheduled to execute at 40 ms intervals.

  Other modules called include
  GKF_FC_KIP - FC Keyboard Interface Processing

- GMA_MIN_EXEC - Minor Cycle Executive
  Scheduled to execute at 40 ms intervals.

  Other modules called include
  GMB_IMU_BITE - IMU Bite Processing
  GMC_ACP_ACUM - IMU Accelerometer Accumulator
  GMD_RES_PROC - IMU Resolver Processor
  GMF_GYO_TORQ - IMU Gyro Torquing
  IMU_RM - IMU Redundancy Management

- GMG_MAJ_EXEC - IMU Major Cycle Executive
  Scheduled to execute at 320 ms intervals when specified IMU functions are to be performed.

Other modules called include
GMH_ACP_COMP - IMU Accelerometer Compensation
GMI_T_UPDATE - IMU Transform Update
GMJ_TOR_TRSF - IMU Torquing Transform
GMK_GYO_COMP - IMU Gyro Compensation
GML_ACP_TRSF - IMU Accelerometer Pulse Transform
GMM_LAT_FUNC - IMU Large Angle Torquing
GMQ_LSF_FILR - IMU Least Squares Filter
IMU_RM - IMU Redundancy Management

5 1 4.2 4 Representation of Processes for Simulation. The DDPS processes listed in the preceding sections have the following common operational characteristics Each is activated by external stimuli (specific events and/or clock pulses) by assigning a CPU to the process on a priority basis, each is subject to interruption for transfer of its assigned processor to a process of higher priority, each process involves the execution of one or more modules of code which are resident in main memory, and, computation associated with performing a process is a function of the state of the system at the time the process is invoked. These characteristics can all be satisfactorily incorporated in the DDPS model if the processes are represented as IMSIM "tasks"

Although ALT design specifications (reference 31) incorporate all input and output initiation in a few "executive" processes, current design specifications for OFT indicate direct data transfer between MDMs and numerous principal functions Actual implementation may confine I/O to executive functions, but this is not assumed to be the case However, this is a moot question insofar as the simulation is concerned, as results of early runs show that I/O activity has negligible impact on execution of principal functions

IMSIM has been augmented with logic for the representation of significant DDPS events and the maintenance of a system state vector These are employed in the definition of "Go/NoGo" functions and "Computation Time" functions. The former are used to control the activation of tasks, and the latter are evaluated when a task is activated to determine the amount of computing to be simulated for the represented process. A detailed description of the represented events and state vector is presented in section 5 2 1

The Computation Time functions are actually associated with routines rather than tasks, and therefore, when a task is activated, the functions for all routines that are elements of the task are evaluated and the results summed The functions

include pseudorandom variables that produce fluctuations in computation for representation of variations in program branching and numeric values (see section 5.2.1 4) In addition, pseudorandom variables are used to round computation and task execution periods to integral milliseconds, since this is the limit of time resolution for the DDPS model. Rounding is performed randomly on each calculated time fraction in direct proportion to its size, i.e , a fraction of 0.8 has an 80% probability of being rounded up to 1 0, and a 20% probability of being truncated to 0.

5.1 4 3 Functional Testing Approach The primary objective of the DDPS study was to analyze the timing relationships between the various elements of the system for the purpose of identifying those areas with a high potential of incurring degradation.

The fundamental approach to the testing was to first make an initial set of simulation runs to determine the overall loading of the system with some emphasis on those potential problem areas identified from the sensitivity analysis (SOW 3.2). The results of the initial set of runs was then used to define any further testing that may be required These additional tests consisted of scenarios that were likely to result in performance degradation, using specific test variations and peak loading inputs While many of these scenarios involved anomalous conditions or responses to malfunctions, they were consistent with realistic operations

In order to keep the simulation runs to a practicable duration, events were scheduled on a condensed timeline The sequence of events within each Major Mode were condensed so that the entire Major Mode can be simulated within a 3-second simulated time span The cyclic nature of the software functions generally results in a fairly uniform loading following an event with major loading changes occurring only in response to the events themselves Thus, each event has an associated loading pattern which can be determined within a fraction of a second after all the activities associated with the event have been initiated Hence, the condensed timelines are intended to give the requisite information within the scheduled simulation time

To generate the condensed runs, nominal events within Major Modes 102, 103, and 104 were sequenced from 50 to 275 ms apart The exact interval depended on the type of run made and was specified by setting the appropriate Savex cell (i.e., X3278) in the initial conditions Thus, the formal sequencing of events was performed by the IMSIM program logic On the other hand, all of the events in Major Mode 101 (Terminal Count) and the extradordinary events (such as Hold Count and Vehicle Safing) occurring in Major Modes 102, 103, or 104 were treated as exogenous events and were initiated through the jobschedule.

5.1 4 4 Approach to System State Simulation and Event Generation. Each of the event occurrences, as specified in Computer Program Development Specification SS-P-0002-510 D (see reference 19) in table 3-3, GN&C--Sequenced Events on pages 3-41 through 3-57--will cause a change in the system state.

The commencement, execution, and termination of Principal Functions are based on the occurrences of these events

Masks for each Major Mode were set up, with bits assigned for each event in that particular Major Mode The simulation of the start, execution, and termination of each of the Principal Functions was based on these masked bits This ensured that all functions operated during the time as specified in table 3-4, GN&C Functions Timeline, in reference 19.

These masks with event occurrence bits for each Major Mode are described in detail in section 5.2 1.1, Savex Cells System Conditions and Settings, of this report

The masked bits have been set up sequentially for normal operations. Extraordinary events such as Hold Count, Vehicle Safing, OMS engine failure, have been assigned separate Savex cells

Event occurrence in Major Mode 101 was generated externally and introduced to the system through the jobschedule This jobschedule is described in detail in section 5 2 4, Model Execution

The normal event occurrences in the other Major Modes (102 through 105) were introduced internally to the program by means of the generation of transactions at periodic intervals set by X3278, which will set the event masks. This generation caused the simulated events to take place in a condensed manner for each Major Mode (approximately 2500 ms for each MM) for a total of 15 seconds.

The code for this generation of event occurrences is described in detail in section 5 2 1 7, Event Generation in NASA - Unique IMSIM revisions.

Event occurrences in Major Mode 102 can also be introduced to the system based on the Mission Elapsed Time (MET) clock as described in section 5.2 1 6, Timing and Clocks

Event generation started at time T_0 - 20 seconds, with event 6, Redundant Set Auto Sequence Start, which started at T_0 - 24 seconds in Major Mode 101, Terminal Count

The extraordinary event occurrences in Major Modes 101 through 105, viz Hold Count (event 9), Resume Count (event 10), Pad Shutdown (event 20), Vehicle Safing (event 23), Left OMS Engine Failure (event 40A), and Right OMS Engine Failure (event 40B), were intended to be executed in the appropriate Major Modes by the setting of the appropriate Savex cells through the jobschedule.

5 1.4 5 Analysis Approach Each of the simulation runs outlined in the preceding sections resulted in numerous real-time and postrun output reports describing the behaviors of several key facets of the simulated configurations. These basic report formats were not altered between runs, nor were the logical conditions that generated these outputs, so that meaningful trends and conclusions could be drawn regarding differences in DDPS system behavior between runs.

The inspection of these outputs in each run followed a logical progression of top-down analysis techniques whereby general conclusions could initially be formed by inspecting overall summary reports, followed by more detailed analyses of the characteristics of individual model components In each case, particular attention was paid to potential key nodes and components in the simulated configuration, in accordance with the conclusions of Task 2, "Sensitivity Analysis" One area that received such special attention is Subsystem Software Interface Processing (SSIP) and its impact on Flight Control (FC) processing. Analysis showed that SSIP processing may pose problems if the SSIP duration is long enough to delay FC processing. This was ascertained by close inspection of the tasks and messages associated with these functions.

Analysis of other potential bottlenecks was made as results from simulation runs were inspected and as additional areas for close scrutiny were uncovered.

5 1.4.5.1 Overall Workload Behavior Initial assessments regarding the acceptability of each run were gained from inspection of several postrun narrative reports that depicted overall configuration behavior Particular emphasis was placed on throughput of simulated software components (jobs, tasks, and messages) Information in these reports that was pertinent to the DDPS was as follows

a. Number of tasks (functions) initiated and successfully completed

b Number of tasks awaiting activation and in ready state

c Number of tasks awaiting message completions

d Number of tasks in active state (i e., presently executing)

e. Number of successful message transmissions, including quantities of messages terminated, with reasons for termination

Of particular interest to DDPS applications were the task completion statistics, which indicated the degree to which workload elements were satisfactorily concluded, and the message transmission statistics, which provided information as to the satisfactory behavior of data bus traffic and of traffic on the channels and data links connecting MDMs and PCMMUs to these buses

5.1.4 5.2 Hardware Component Utilization. Following the initial inspections of workload summary statistics, attention was directed towards utilization statistics that detailed the behavior of individual hardware components. Specific component utilization reports that had meaning for the DDPS configuration were as follows

a. Processor utilization. number of times used, total time in use, and percentage of time in use during each run for each processor.

b Data link utilization number of associated transmissions, average time per transmission, and percentage of time in use during each run for each data link

c Device utilization number of associated transmissions, average time per transmission, and percentage of time in use during each run for each device.

The processor utilization data were of interest in assessing the degree to which the GPC computers were used in each run, and thus indicated the degree to which these units were saturated during these tests. Utilization figures on data links and devices were inspected to note abnormally low or high use of these components for selected runs. Inordinately low usages of these components could indicate the need for reallocation or reconfiguration of such units for more efficient utilization, while high-usage statistics could infer the need for additional components or a restructuring of the workload to alleviate saturation conditions and potential bottlenecks

5.1 4 5.3 Software Component Utilization Based on inspections of the overall workload summaries and hardware component statistics, attention was oriented toward the behavior of specific tasks and messages The following kinds of information were gathered for specified components·

a Task behavior for each given task type (e g , user interface, ascent digital autopilot), tabulations were made of maximum time required for completion per run, number of times invoked, and number of times interrupted

b Message behavior. for each given message type (e.g., write commands to EIU, reading of RCS propellant temperatures), tabulations were made of maximum time for transmission per run, number of times initiated, and number of times interrupted.

These data were augmented by other specialized reports to further depict the characteristics of software components that were executed several times in the course of a test run, so as to gain insight into the timeline dynamics of tasks and messages of significant interest

5 1 4 5.4 Transaction Analysis The generalized workload summaries and component-specific tabulations described in the preceding sections permitted efficient analysis of the behavior of simulated portions of the system as parametrically input to IMSIM. In addition to these model-related statistics, several postrun transaction-oriented reports generated by IMSIM's host interpreter "MODLIT" were employed to augment these IMSIM component statistics. This was accomplished by generating data relating to generalized MODLIT components. Such reports were used to isolate inordinate backlogs and bottlenecks occurring in these runs, with emphasis on the flow of MODLIT traffic elements (transactions) through static MODLIT system entities (blocks) Data that were so utilized were as follows:

a. Key block summary. an abbreviated summary of the behavior of key blocks in the model provided, for each block, the transaction backlog (maximum, average, and current) and the average transaction delay (for all transactions and for delayed transactions only).

b. Detailed block printout. a full summary of the behavior of every block in the model provided, for each block, the number of transactions through the block, the transaction backlog (maximum, average, and current) and the average transaction delay (for all transactions and for delayed transactions only)

c Activity summary· a tabulation of the detailed model traffic that was totaled according to specific type of MODLIT operations produced the following information

1. CURRENT TRANSACTION COUNT
2 MAXIMUM NUMBER OF TRANSACTIONS
3. NUMBER OF TRY OPERATIONS
4 NUMBER OF TRANSACTION MOVES
5 NUMBER OF VARIABLE EVALUATIONS
6. MAXIMUM VARIABLE RECURSION
7 NUMBER OF ADMIT ATTEMPTS
8 NUMBER OF FUNCTION POINTS
9. MOST RECENT BLOCK ID
10. NUMBER OF BLOCK SPACES USED
11. NUMBER OF REPORT LINES
12. NUMBER OF VARIABLE ELEMENTS
13 CURRENT UTILIZATION OF STACKS

d. Task scheduling queues: a summary of task backlogs were generated for the runs, including total number invoked (delayed and undelayed), queue length (maximum, current, and average), and average wait (all units and delayed units only)

e. Detailed transaction summaries tabulations of data that specified the status of one or more selected transactions were produced, including associated transaction parameters (up to five), current transaction priority, and associated parameter stack entries for each transaction.

f Facility reports MODLIT summaries of processor, data link, and device behavior were output to supplement those produced by IMSIM, including utilization statistics, current priority, current recourse (MODLIT block to which the current user will be routed if evicted), and number of transactions evicted without recourse.

These reports were thus employed to provide more detailed analysis of model behavior so as to determine specific causes for system problems that were uncovered in the more general analyses of the IMSIM reports.

5.1.4 5 5 Detailed Real-Time Workload Flow. Based on the preceding analyses, it was sometimes desirable to trace the progress of individual jobs, tasks, and messages as they progressed through the network. For this reason, the following reports were provided, and were generated immediately as each respective event occurred

a. Job progress reports. start time, completion time, and elapsed time for each job

b. Task progress reports start time, wait time, execution time, and completion time for each task.

c Message progress reports· start and end times (including associated task and job)

These reports permitted the tracing of the characteristics of specific software components in simulated real time This was especially helpful for suspected jobs, tasks, or messages that appeared to be causing inordinate backlogs, delays, or resource utilizations in the configurations under test

A Master Task list was compiled giving all pertinent details for each Principal Function, to facilitate analysis of executed simulation runs This Master Task list is given in table 5-2.

Table 5-2. Master Task List

INIT	Task	Task Index	Repeat Task	Job	Relat Prio	Activation				Termination				Exec Rate	Interval	
						mode	Savex	Event	bit	mode	Savex	Event	bit		ms	Savex
	6	706		2	10	102	644	19	1	103	645	28	1	6.25	160/500	3273
	7	707		2	10	103	645	28	1	103	645	32	32	0 5	2000	3271
	8	708	501	2	10	104	646	36	1	105	646	44	256	0.5	2000	3271
	15	709		2	14	101	643	14	128	106	647	50	512	0.25	4000	3272
	19	710	502	2	15	101	643	14	128	103	645	32	32	6 25	VAR	3274
	36	711		2	44	103	645	32	32	103	645	34	256	25 0	40	3261
*	40	726		3	38	101	-	1	-	106	-	50	-	25 0	40	3261
*	41	727		3	39	101	-	1	-	103	645	28	1	25 0	40	3261
*	42	728		3	26	101	-	1	-	103	645	28	1	25 0	40	3261
	45	729		3	19	103	645	34	256	104	646	36	1	6 25	160	3263
*	49	730		3	18	101	-	1	-	104	646	43A	128	6 25	160	3263
*	50	731		3	36	101	-	1	-	104	646	43A	128	25 0	40	3261
*	52	712		2	30	101	-	4	-	104	646	43A	128	25.0	40	3261
	54	732		3	25	103	645	33	64	106	647	50	512	12 5	80	3262
*	60	733		3	40	101	-	1	-	104	646	43A	128	25.0	40	3261
*	62	734		3	41	101	-	1	-	103	645	28	1	25 0	40	3261
	64	735	503	3	41	103	645	33	64	105	647	45	4	25 0	40	3261
	65	736	504	3	42	103	645	33	64	105	647	46	8	25.0	40	3261
	70	746		4	17	103	645	33A	128	104	646	43A	128	6 25	160	3263
*	91	747		4	31	101	-	1	-	106	-	50	-	25 0	40	3261
	92	748	505	4	27	104	646	37	2	106	647	49	256	25 0	40	3261
*	95	749		4	8	101	-	1	-	104	646	43A	128	3.125	320	3264

* Initially operating tasks.

Table 5-2 (cont)

INIT	Task	Task Index	Repeat Task	Job	Relat Prio	Activation				Termination				Exec Rate	Interval	
						mode	Savex	Event	bit	mode	Savex	Event	bit		ms	Savex
	97	713		2	34	101	643	14	128	106	647	50	512	6 25	160	3263
*	101	737		3	4	101	-	1	-	106	647	50	512	1 0	1000	3270
*	102	738		3	5	101	-	1	-	106	647	50	512	1 0	1000	3270
*	110	750		4	6	101	-	1	-	106	647	50	512	1.0	1000	3270
*	114	751		4	25	101	-	1	-	102	644	19	1	12 5	80	3262
	115	752		4	44	102	644	25	64	103	645	28	1	25 0	40	3261
	116	753		4	44	103	645	33	64	104	646	38	4	25.0	40	3261
*	119	739		3	28	101	-	4	-	104	646	43A	128	25 0	40	3261
*	120	740		3	29	101	-	1	-	103	645	28	1	25.0	40	3261
	161	754	506	4	17	101	643	13	32	101	643	13T	64	6 25	160	3263
	164	755		4	32	102	644	24	16	102	644	24T	32	25 0	40	3261
	165	714		2	46	102	644	19	1	103	645	34	256	25 0	40	3261
	168	715		2	12	101	643	14	128	106	647	50	512	6.25	160	3263
	171	741		3	23	103	645	34	256	106	647	50	512	12.5	80	3262
	175	756		4	35	102	644	19	1	106	647	50	512	25.0	40	3261
*	176	716		2	42	101	-	5	-	103	645	33	64	25 0	40	3261
*	180	717		2	21	101	-	1	-	106	-	50	-	12.5	80	3262
*	181	742		3	45	101	-	1	-	104	646	43A	128	25.0	40	3261
	182	757	507	4	43	104	646	37	2	104	646	42A	64	25.0	40	3261
	183	758	508	4	17	103	645	33	64	104	646	42A	64	6.25	160	3263
	188	743		3	32	101	643	8	4	101	643	8A	8	25.0	40	3261
	190	744		3	32	103	645	32	32	106	647	50	512	25.0	40	3261

* Initially operating tasks

Table 5-2 (cont)

INIT	Task	Task Index	Repeat Task	Job	Relat Prio	Activation				Termination				Exec Rate	Interval	
						mode	Savex	Event	bit	mode	Savex	Event	bit		ms	Savex
	193	745		3	32	102	644	19	1	103	645	28	1	25.0	40	3261
	197	718		2	2	101	643	14	128	106	647	50	512	0 5	2000	3271
	201	719		2	37	103	645	34	256	106	647	50	512	25 0	40	3261
*	203	720		2	33	101	-	1	-	103	645	28	1	25 0	40	3261
*	206	721		2	0	101	-	1	-	104	646	36	1	0 5	2000/500	3275
	210	722		2	0	104	646	36	1	106	647	50	512	0 5	2000	3271
*	306	723		2	48	101	-	1	-	106	-	50	-	25 0	40	3261
*	307	759		5	49	101	-	1	-	106	-	50	-	25.0	40	3261
*	309	724		2	47	101	-	1	-	106	-	50	-	25.0	40	3261
*	319	725		2	9	101	-	1	-	106	-	50	-	3 125	320	3264
*	332	760		5	11	101	-	1	-	106	-	50	-	5.0	200	3268
	333	761		5	23	101	643	1	1	102	644	19	1	25 0	40	3261
	334	762	Request	5	19	-	-	-	-	-	-	-	-	-	2	3276
*	335	763		5	1	101	-	1	-	106	-	50	-	10 0	100	3267
*	337	764		5	3	101	-	1	-	106	-	50	-	1.0	1000	3270
	501	708		2	10	105	647	45	4	106	647	49	256	0.5	2000	3271
	502	710	601	2	15	104	646	36	1	105	647	44	1	6.25	Varies	3274
	503	735		3	41	105	647	45	4	105	647	48A	128	25.0	40	3261
	504	736		3	42	105	647	45	4	105	647	48A	128	25.0	40	3261
	505	748		4	27	105	647	46	8	105	647	49	256	25.0	40	3261
	506	754		4	17	102	644	22	4	102	644	22T	8	6 25	160	3263
	507	757		4	43	105	647	46	8	105	647	48A	64	25.0	40	3261

* Initially operating tasks.

Table 5-2 (cont)

INIT	Task	Task Index	Repeat Task	Job	Relat Prio	Activation				Termination				Exec Rate Hz	Interval	
						mode	Savex	Event	bit	mode	Savex	Event	bit		ms	Savex
	508	758		4	17	105	647	40A	16	105	647	48A	128	6.25	160	3263
	601	710		2	15	105	647	46	4	105	647	49	256	6.25	Varies	3274

5 2 TASK PERFORMED

This section discusses the activities performed under each of the five tasks specified in the Statement of Work (section 3 of exhibit "A" of contract NAS 9-15010)

5 2 1 Requirements Definition and Adaptation of Simulation Model (SOW 3 1)

All documentation received from NASA (references 6 through 21) was analyzed, and a thorough understanding of the functional requirements for the Space Shuttle Orbiter's hardware and software was gained.

In close coordination with NASA a baseline for the simulation model was developed,viz the Ascent Phase (OPS 1) of the Orbital Flight Test (OFT) configuration. Start time of simulation was to be at T_0-20 seconds when Event 6 had taken place Guidance, Navigation, and Control will be the only Major Function operating during this phase

The Principal Functions for Guidance, Navigation , and Control, as described in reference 19 which will execute during the Ascent phase, were defined as well as their associated functions, programs, and modules (see table 5-1).

Priorities for each of the Principal Functions were established with the cyclic execution rates of these Principal Functions as the guiding factor, i e., functions with the highest execution rates will have the highest priorities.

Execution times for the Principal Functions' programs and modules were established based on the Function Flow charts and function descriptions in the FSSR documents.

A substantial amount of time was expended on the calculation of these execution times as these functions were projected down to the instruction level Based on this analysis and the available IBM instruction execution times, values were established for these functions.

Details on these calculations are contained in section 5.2.1 4.

The systems requirements as defined above for the hardware and software of the Space Shuttle's OFT Configuration were subsequently transformed into a form suitable for IMSIM and resulted in this simulation model version.

This model's adaptation is detailed in the sections 5 2.1.1 through 5.2 1.9 below, and the parameterization of the model is detailed in sections 5.2.3.2 through 5.2 3.3

5 2.1 1 Savex System Conditions and Settings. A group of Savex cells has been designated and used for NASA-unique conditional requirements, system conditions, counters, clocks, event masks, and miscellaneous functions

Savex cells 643 through 647 are used for the event masks in each of the Major Modes, and the bit position determines the event which causes a change in the system state In Major Mode 101,these events are basically a function of the countdown clock, in the other Major Modes these bits are generated at specific intervals.

Savex cells 3261 through 3276 are used by the Principal Functions to determine the execution rates at which each function is to operate

Table 5-3, Savex cells Use for OFT, presents the utilization of these Savex cells with the values associated with their use.

Table 5-3. Savex Cells Use for OFT

```
''SAVEX CELLS -NASA.SAV11.DATA - UTIL. FOR OFT  23 DEC 1976

''NASA COMMENTS ON TEST PLAN INCORPORATED 6 DEC 1976

X(V107)  -  TASK NUMBER FOR PRINCIPAL FUNCTION
            USED IN V328, V338, V339, V344, V346, V361, V363,
            V365, V370, V379, V387, V396, V397, V398, V402,
            V426, V437, V441, V446, V448, & V299

X568  -  TASK ACTIVATION SAVEX
           USED IN V402

X577  -  TASK NUMBER FOR ACTIVATION
           USED IN V436

X638  -  START TIME GROUP 1 FUNCTIONS (CONTINUOUS FUNCTIONS)

X639  -  START TIME GROUP 2 FUNCTIONS (TERMINATING FUNCTIONS)

X640  -  START TIME COMMUNICATIONS REGISTER

X641  -  START TIME GROUP 4 FUNCTIONS (USER INTERFACE FUNCTION)

X642  -  REFERENCE TIME FOR UTILIZATION REPORTS
           USED IN V442 & V445

X643  - EVENT MASK     1 = EV. 6 - R/S AUTO SEQ START          BIT   1
         FOR MM101:    2 = EV. 7 - FORCE OVERRIDE SRB ACT      BIT   2
                       4 = EV. 8 - SRB FCS/HYD VERIFICATION    BIT   3
                       8 = EV. 8A- SRB FCS/HYD VERIF COMPLETE  BIT   4
                           EV. 9 - HOLD COUNT                    X675
                           EV.10 - RESUME COUNT                  X675
                      16 = EV.11 - PLATFORM                    BIT   5
                      32 = EV.13 - VENT DOORS CLOSE CMD        BIT   6
                      64 = EV.13T- VENT DOORS CLOSED           BIT   7
                     128 = EV.14 - NAVIGATION INITIATION       BIT   8
                     256 = EV.15 - GO FOR SSME START           BIT   9
                     512 = EV.16 - FORCE OVERRIDE MPS ACT.     BIT  10
                    1024 = EV.17 - SSME START                  BIT  11
                    2048 = EV.19 - SRB IGNITION CMD            BIT  12
         X643 USED IN V341
```

Table 5-3 (cont)

X644 - EVENT MASK FOR MM102:	1 =	EV.19 - SRB IGNITION START	BIT	1
		EV 20 - PAD SHUTDOWN	X693	
	2 =	EV.21 - TOWER CLEAR	BIT	2
	4 =	EV.22 - OPEN VENT DOORS CMD	BIT	3
	8 =	EV.22T- VENT DOORS OPENED	BIT	4
		EV 23 - VEHICLE SAFING	X687	
	16 =	EV.24 - SAFE SRB RANGE SAFETY STRT	BIT	5
	32 =	EV.24T-SAFE SRB RANGE SAFETY END	BIT	6
	64 =	EV.25 - SRB SEPARATION MONITOR	BIT	7
	128 =	EV.26 - SRB SEPARATION INITIATION	BIT	8
	256 =	EV.27 - FUNCTION MODING FOR SEP	BIT	9
	512 =	EV.28 - SRB SEPARATION COMMAND	BIT	10
X644 USED IN V326				
X645 - EVENT MASK FOR MM103:	1 =	EV.28 - SRB SEPARATION COMMAND	BIT	1
	2 =	EV.29 - GUIDANCE INITIATE	BIT	2
	4 =	EV.30 - MPS LOW LEVEL SENSOR ACTIV	BIT	3
	8 =	EV.30A- FCS TVC RE-TRIM	BIT	4
	16 =	EV.31 - MECO MONITOR	BIT	5
	32 =	EV.32 - MECO COMMAND	BIT	6
	64 =	EV.33 - MECO CONFIRMED	BIT	7
	128 =	EV.33A- ENABLE MPS DUMP	BIT	8
	256 =	EV 34 - ET SEPARATION COMMAND	BIT	9
	512 =	EV.35 - SEPARATION MANEUVER COMPL	BIT	10
	1024 =	EV.36 - MM TRANSITION TO MM104	BIT	11
X645 USED IN V345 & V438				
X646 - EVENT MASK FOR MM104	1 =	EV.36 - MM TRANSITION TO MM104	BIT	1
	2 =	EV 37 - OMS IGNITION COMMAND	BIT	2
	4 =	EV.38 - OMS IGNITION CONFIRMATION	BIT	3
	8 =	EV.39 - ACTIVE GUIDANCE	BIT	4
		EV.40A- LEFT OMS ENGINE FAILURE	X685	
		EV.40B- RIGHT OMS ENGINE FAILURE	X685	
	16 =	EV.41A- OMS CUTOFF PREDICTED	BIT	5
	32 =	EV.42 - OMS CUTOFF	BIT	6
	64 =	EV.42A- OMS CUTOFF CONFIRMATION	BIT	7
	128 =	EV.43A- TERMINATE MPS DUMP	BIT	8
	256 =	EV.44 - MODE TRANSITION TO MM105	BIT	9
X646 USED IN V403				

Table 5-3 (cont)

```
X647  - EVENT MASK      1 = EV.44 - MODE TRANSITION TO MM105      BIT   1
        FOR MM105       2 = EV.44A- TRIM OMS GIMBALS              BIT   2
                        4 = EV.45 - INITIATE GUIDANCE             BIT   3
                        8 = EV.46 - OMS IGNITION COMMAND          BIT   4
                       16 = EV.47 - OMS IGNITION CONFIRMATION     BIT   5
                       32 = EV.47A- OMS CUTOFF PREDICTED          BIT   6
                       64 = EV.48 - OMS CUTOFF                    BIT   7
                      128 = EV.48A- OMS CUTOFF CONFIRMATION       BIT   8

                      256 = EV.49 - MODE TRANSITION TO MM106      BIT   9
                      512 = EV.50 - OPS TRANSITION TO GN&C8       BIT  10
          X647 USED IN V403 & V448

X656  -  40 MS TIME SLICE COUNTER
           USED IN V414, V428, V429, V449

X657  -  80 MS TIME SLICE COUNTER . 1 - 12
           USED IN V343, V377, V394

X659  -  FUNCTION ABORT COUNTER

X660  - TIME SLICE  00000 = 40 MS
        PROCESSING  00001 = 80 MS
                    00010 = 160 MS
                    00100 = 320 MS
                    01000 = 1000 MS
                    10000 = 2000 MS
             USED IN V366 & V371

X661  - COUNTDOWN CLOCK IN SECONDS (EV 6,7,8,11,13,14,15,17,19)
           USED IN V341

X662  - START OF MISSION ELAPSED TIME (MET) CLOCK IN MS (EV.22,24,25,26)
           USED IN V417
```

Table 5-3 (cont)

X663	- GN&C MAJOR MODES & OPS·	000 = NULL 100 = OPS 1 - ASCENT OPERATIONS 101 = TERMINAL COUNT 102 = FIRST STAGE 103 = SECOND STAGE 104 = OMS 1 INSERTION 105 = OMS 2 INSERTION 106 = INSERTION COAST 200 = OPS 2 - ORBIT OPERATIONS 201 = ORBIT COAST 202 = MANEUVER 1 EXECUTE 211 = RENDEZVOUS NAV 213 = TPF/STATION KEEPING 300 = OPS 3 - ENTRY OPERATIONS 301 = PREDEORBIT COAST 302 = DEORBIT EXECUTION 303 = PRE-ENTRY MONITOR 304 = ENTRY 305 = TAEM 306 = APPROACH & LANDING 600 = OPS 6 - RTLS OPERATIONS 601 = RTLS SECOND STAGE 602 = RTLS ENTRY 603 = RTLS TAEM 800 = OPS 8 - VU ORBIT CHECKOUT 900 = OPS 9 - VU PRECOUNT
	X663 USED IN V327, V329, V330, V331, V332, V333, V334, V353, V369, V378	
X666	- GN&C CURRENT MAJOR MODE	

Table 5-3 (cont)

X669 -	KEYBRD & APPLICAT. CONTROL:	00 = NULL		
		01 = OPS	MODE CHANGE	
		02 = SPEC	SPECIALIST FUNCTIONS	
		03 = DISPLAY	DISPLAY FUNCTIONS	
		04 = ITEM	SIM	
		05 = RESUME	SIM	
		06 = CLEAR	NO SIM	
		07 = ENTER	NO SIM	
		08 = PRO	SIM	(EVENT 49)
		09 = EXEC	SIM	
		10 = MSG RESET	NO SIM	
		11 = XFER	NO SIM	
		12 = ACKNOWL	NO SIM	
		13 = FAULT SUMM	NO SIM	
		14 = GPC/CRT	NO SIM	
		15 = SYS SUMM	NO SIM	
X669 USED IN V350, V352, V385, V388, V431, V432, V433, V434				
X670 -	SPEC FUNCTIONS.	01 = ORBIT IMU CNTL/MON		
		03 = RM/CONTROLLERS		
		04 = RM/SWITCHES-FDBCK		
		05 = RM/SENSORS		
		06 = NAV/TGT UPDATE		
		07 = HORIZ SIT		
		08 = ORBIT DAP CONFIG		
		09 = REL MOTION		
		10 = RNDZ TGTING		
		13 = UNIVERSAL POINTING		
		15 = RM/OMS		
		16 = RM/RCS		
		17 = VENT DOOR CNTL		
X671 -	NUMERICAL KEYBOARD INPUTS · 1 - 99 USED IN V439			

Table 5-3 (cont)

```
X672  -  NAVIGA-      01 = AUTO-P
          TIONAL      02 = AUTO-RY
          STATES.     03 = AUTO-BF
                      11 = CAS-P
                      12 = CAS-RY
                      13 = CAS-BF
                      21 = MD-P
                      22 = MD-RY
                      23 = MD-BF
        X672 USED IN V331

X673  -  FLIGHT       00000 = NULL
          CONDITIONS. 00001 = IMU PLATFORM RELEASED
                USED IN V367

X674  -  DISPLAY·     00 = CURRENT DISPLAY
                      01 = CURRENT DISPLAY UPDATE
                      02 = NEW DISPLAY
        X674 USED IN V391 & V435

X675  - COUNTDOWN.    00 = NULL
                      01 = HOLD COUNT COMMAND   (EVENT 9)
                      02 = RESUME COUNT COMMAND   (EVENT 10)

X678 - OMS FUEL       00 = NULL
           VALVES:    01 = POSITION OK
                      02 = POSITIONING FAIL
        X678 USED IN V342

X685 - OMS FAILURE:   00 = NULL
                      01 = LEFT OMS FAILURE  (EVENT 40A)
                      02 = RIGHT OMS FAILURE  (EVENT 40B)
         X685 USED IN V342 & V408

X686 - MPS DUMP:      00 = NULL
                      01 = MPS PREVALVE CLOSE CMD

X687 - VEHICLE        00 = NULL
         SAFING       01 = SSME OUT    (EVENT 23)
           X687 USED IN V332 & V336
```

Table 5-3 (cont)

```
X688 - 40 MS COUNTER (0 - 4)
          USED IN V333 & V428

X690 - FAULTY          00 = NULL
   THRUSTER INDIC:     01 = FAULTY THRUSTER INDICATOR
         X690 USED IN V344

X691  - A/L GUIDANCE.  01 = TRAJECTORY CAPTURE
                       02 = STEEP GLIDE SLOPE
                       03 = SHALLOW GLIDE SLOPE
                       04 = FINAL FLARE

X692 - TOWER           00 = NULL
        CLEARANCE      01 = TOWER CLEAR    (EVENT 21)
                       02 = NOT CLEARED

X693  - PAD SHUT-      00 = NULL
         DOWN          01  INITIATE PAD SHUTDOWN SEQ  (EVENT 20)

X694  -  DOWNLIST     00 = NOT ENABLED
                       01 = DOWNLIST ENABLED

X695  -  TERMINATE     00 = NO TERMINATE ACTION
          INDICATOR    01 = TERMINATE ACTION TAKEN
            X695 USED IN V439

X696  -  LIGHT         00 = NO LIGHT ALARM
          ALARM:       01 = LIGHT ALARM EVENT
            X696 USED IN V430

X697  -  TIME MGT      00 = NOT ENABLED
                       01 = TIME MANAGEMENT ENABLED

X698  -  START TIME FOR EVENT MASK GENERATION

X699  - START TIME FOR COUNTDOWN CLOCK
```

Table 5-3 (cont)

X3251 - COUNTER FOR CONTINUOUS FUNCTIONS

X3252 - COUNTER FOR INITIAL FUNCTIONS THAT TERMINATE DURING OPS1

X3253 - NUMBER OF TASKS FOR INDEXING INTO 1ST BLOCK OF V421 = 15

X3254 - NUMBER OF TASKS FOR INDEXING INTO V409 = 30

X3255 - COUNTER FOR TASKS GENERATED IN BLOCK 20000

X3256 - COUNTDOWN TIME IN MS IN REAL TIME UNTIL LIFTOFF

X3257 - INTERVAL FOR COUNTDOWN CLOCK X661

X3258 - REPORTS 36 , 38, AND 40 PRINT CONTROL

X3259 - REPORT 37 PRINT CONTROL

X3260 - DELAY FOR COUNTDOWN CLOCK IN TRANSITION

X3261 - FUNCTION CYCLE INTERVAL = 40 MS

X3262 - FUNCTION CYCLE INTERVAL = 80 MS

X3263 - FUNCTION CYCLE INTERVAL = 160 MS

X3264 - FUNCTION CYCLE INTERVAL = 320 MS

Table 5-3 (cont)

X3265 - FUNCTION CYCLE INTERVAL = 960 MS

X3266 - FUNCTION CYCLE INTERVAL = 50 MS

X3267 - FUNCTION CYCLE INTERVAL = 100 MS

X3268 - FUNCTION CYCLE INTERVAL = 200 MS

X3269 - FUNCTION CYCLE INTERVAL = 500 MS

X3270 - FUNCTION CYCLE INTERVAL = 1000 MS

X3271 - FUNCTION CYCLE INTERVAL = 2000 MS

X3272 - FUNCTION CYCLE INTERVAL = 4000 MS

X3273 - FUNCTION CYCLE INTERVAL CHANGE 160/500 MS (TASK 6)

X3274 - FUNCTION CYCLE INTERV CHANGE 2000/160/500/2000/500/2000 MS -(19)

X3275 - FUNCTION CYCLE INTERVAL CHANGE 2000/500 MS (TASK 206)

X3276 - FUNCTION CYCLE INTERVAL 2 MS (TASK 334)

X3277 - JOBSCHEDULE TIME FOR START MM102

X3278 - INTERVAL FOR EVENT GENERATION SCHEDULE

X3280 - TEMP EVENT COUNTER FOR EVENT 40

5 2 1.2 Initial Conditions. Initial Conditions were set at the start of each simulation. The setting of these conditions was accomplished by the setting of those Savex cells and gates that represent the state of the system at the start of a run

Three sets of Initial Conditions were developed, which supplement each other, viz ·

a. For start of Countdown mode 101 at T_0 - 20 seconds

b For start at T_0 - 1 second and go through zero countdown, liftoff, and transition to first stage mode 102

c For start at 1 second prior to SRB Separation in Major Mode 102 to go through transition to Major Mode 103 (Second Stage).

d. For start at ET Separation complete in Major Mode 103, to go through transition to Major Mode 104 (OMS 1 Insertion)

5 2.1 2 1 Initial Conditions at T_0 - 20 Seconds. The setting of these Savex cells requires the IMSIM model to start task initiations at 100 ms after run start The countdown clock is set to start at T_0 - 20 seconds and the Mission Elapsed Time (MET) clock to an arbitrary high number that will be cleared the moment the countdown clock goes to zero.

Initial OPS is set to "Ascent Operations - OPS 1" and the initial Major Mode to "Terminal Count - MM101"

The initial cyclic interval for each of the Principal Functions is set in Savex cells 3261 through 3276

These Initial Conditions are given in table 5-4

Table 5-4 Initial Conditions for MM101

```
S X642 = 100              ''REFERENCE TIME FOR SIMULATION START
S X640 = X642 - 2         ''COMMUNICATION REGISTER FOR COORD START TIMES
S X638 = X640             ''START TIME FOR CONTINUOUS FUNCTIONS
S X639 = X640             ''START TIME FOR TERMINATING FUNCTIONS
S X641 = X640             ''START TIME USER INTERFACE FUNCTION
S X643 =  1               ''MAJOR MODE 101, EVENT 6
S X662 = 9999999          ''MET CLOCK PRIOR TO LIFTOFF
S X663 = 101              ''GN&C OPS 1 - MAJOR MODE 101
S X666 = 101              ''CURRENT GN & C MODE
S X672 =  1               ''NAV STATE. AUTO-P
S X673 = 001              ''IMU PLATFORM RELEASED
S X694 =  1               ''DOWNLIST ENABLED
S X697 =  1               ''TIME MANAGEMENT ENABLED
S X698 =  X640            ''START TIME FOR EVENT MASK GENERATION
S X3253 = 15              ''NUMBER OF FUNCTIONS GENERATED BY 20040
S X3251 = X3253           ''INDEXING INTO BLOCK 2 OF V421
S X3254 = 30              ''NUMBER OF FUNCTIONS TO BE GEN IN V409
S X3256 = 20000           ''COUNTDOWN CLOCK IN MS (-20.000 SEC)
S X3277 = 2000            ''JOBSCHEDULE START FOR MM 102
S X3257 = V406            ''INTERVAL FOR COUNTDOWN COUNTER/FNC OF X3256
S X3260 = X3257           ''DELAY FOR LAST COUNTDOWN
S X661  = V355            ''INITIAL COUNTDOWN COUNTER/FNC OF X3277
S X3258 = 1               ''PRINT REPORT 36 WHEN APPROPRIATE
S X3259 = 1               ''PRINT REPORT 37 WHEN APPROPRIATE
S X3261 = 40              ''40 MS CYCLIC INTERVAL
S X3262 = 80              ''80 MS CYCLIC INTERVAL
S X3263 = 160             ''160 MS CYCLIC INTERVAL
S X3264 = 320             ''320 MS CYCLIC INTERVAL
S X3265 = 960             ''960 MS CYCLIC INTERVAL
S X3266 = 50              ''50 MS CYCLIC INTERVAL
S X3267 = 100             ''100 MS CYCLIC INTERVAL
S X3268 = 200             ''200 MS CYCLIC INTERVAL
S X3269 = 500             ''500 MS CYCLIC INTERVAL
S X3270 = 1000            ''1000 MS CYCLIC INTERVAL
S X3271 = 2000            ''2000 MS CYCLIC INTERVAL
S X3272 = 4000            ''4000 MS CYCLIC INTERVAL
S X3273 = 160             ''160/500 MS CYCLIC INTERV CHANGE (TASK 6)
S X3274 = 2000            ''2000/160/500/2000/500/2000 MS CYCL.CHANGE (19)
S X3275 = 2000            ''2000/500 MS CYCLIC INTERVAL CHANGE (TASK 206)
S X3276 = 2               ''2 MS CYCLIC INTERVAL (TASK 334)
S X3278 = 175             ''INTERVAL FOR EVENT GENERATION
S G43 = 1                 ''FOR PRINTING TASK HISTORY
S G44 = 1                 ''FOR PRINTING MESSAGE HISTORY
```

5 2.1.2 2 Initial Conditions at T_0 - 1 Second The setting of these Savex cells override the setting of the same numbered Savex cells as done in section 5 2.1.2 1. The other Savex cells remain unchanged.

The setting of these Savex cells as given in table 5-5, requires the IMSIM model to start task initiations at 1900 ms after the start. The Countdown clock is set to -1 (X3256 and X661). The event mask (X643) is set to the start of event 17 in Major Mode 101 This run start will force the IMSIM model to go through the last second of Countdown in Major Mode 101, go through transition to Major Mode 102 and continue in the First Stage mode with events taking place as described in section 5 2.1 3.

These Initial Conditions are given in table 5-5.

Table 5-5. Initial Conditions for Transition from Major Mode 101 to Major Mode 102

```
S X3256 = 1000          ''COUNTDOWN CLOCK IN MS
S X3257 = 100           ''INTERVAL FOR COUNTDOWN COUNTER
S X3260 = 1998          ''DELAY FOR LAST COUNTDOWN
S X3277 = 2000          ''JOBSCHEDULE START FOR MM102
S X3278 = 50            ''INTERVAL FOR EVENT GENERATION
S X661 = 1              ''COUNTDOWN COUNTER
S X642 = 1900           ''REFERENCE TIME FOR SIMULATION START
S X638 = 1898           ''START TIME FOR CONTINUOUS FUNCTIONS
S X639 = 1898           ''START TIME FOR TERMINATING FUNCTIONS
S X640 = 1898           ''COMMUNICATION REGISTER FOR COORD START TIMES
S X641 = 1898           ''START TIME USER INTERFACE FUNCTIONS
S X698 = 1898           ''START TIME FOR EVENT MASK GENERATION
S X643 = 1024           ''SET EVENT 17 - SSME START - IN MM101
```

5.2.1.2 3 Initial Conditions Transition from Major Mode 102 to Major Mode 103. The setting of these Savex cells override the setting of the same numbered Savex cells as done in sections 5.2.1.2.1 and 5.2 1.2.2

The other Savex cells remain unchanged. By resetting these Savex cells as given in Table 5-6, the model is forced to start task initiations at 120,000 ms (120 seconds after liftoff) after simulation run start

The Major Mode is set to 102 with event 27 in that mode starting (X644), and all prior events have taken place (X643 = 2048).

MET Clock is set to 120 seconds (X662) These Initial Conditions require the model to go through the last events in Major Mode 102, go through the transition to Major Mode 103 and continue the Second Stage mode with events taking place as described in section 5.2 1.3.

These Initial Conditions are given in table 5-6

Table 5-6. Initial Conditions for Transition from Major Mode 102 to Major Mode 103

```
S X3256 = 0              ''COUNTDOWN CLOCK IN MS
S X3273 = 500            ''CYCLIC INTERVAL FOR TASK 6
S X3274 = 2000           ''CYCLIC INTERVAL FOR TASK 19
S X3275 = 2000           ''CYCLIC INTERVAL FOR TASK 206
S X3277 = 120000         ''START TIME FOR MM103
S X3278 = 50             ''INTERVAL FOR EVENT GENERATION
S X3280 = 27             ''EVENT COUNTER
S X661 = 0               ''COUNTDOWN COUNTER
S X662 = 120000          ''MET CLOCK START
S X663 = 102             ''GN&C OPS 1 - MAJOR MODE 102
S X666 = 102             ''CURRENT MAJOR MODE
S X642 = 120000          ''REFERENCE TIME FOR SIMULATION START
S X638 = 119998          ''START TIME FOR CONTINUOUS FUNCTIONS
S X639 = 119998          ''START TIME FOR TERMINATING FUNCTIONS
S X640 = 119998          ''COMM REGISTER FOR COORD START TIMES
S X641 = 119998          ''START TIME USER INTERFACE FUNCTIONS
S X698 = 119998          ''START TIME FOR EVENT MASK GENERATION
S X643 = 2048            ''ALL EVENTS  MM101 OCCURRED
S X644 =  256            ''SET EVENT 27 - MODING FOR SEP - IN MM102
```

5.2 1.2.4 Initial Conditions for Transition from Major Mode 103 to Major Mode 104 The conditions in table 5-7 were used in the simulation runs for Major Mode 104--OMS 1 Insertion. The setting of these Savex cells override the setting of the same numbered Savex cells as given in section 5.2.1.2.1, 5.2 1.2 2, and 5.2 1.2.3 The other Savex cells remain unchanged.

By setting these cells as given, the model is forced to start task initiations at 240,000 ms (240 sec) after simulation run start. The Major Mode is set to 103 with Event 36 in that mode starting (X645), and all events prior having occurred (X644 = 512) The MET Clock is set to 240 seconds (X662).

These Initial Conditions require the model to go through the last event in Major Mode 103, go through the transition to Major Mode 104, and continue the OMS 1 Insertion mode with events taking place as described in section 5.2 1.3

These Initial Conditions are given in Table 5-7.

Table 5-7. Initial Conditions for Transition from Major Mode 103 to Major Mode 104

```
S X3277 = 240000          ''START TIME FOR MM104
S X3278 = 275             ''INTERVAL FOR EVENT GENERATION
S X3280 = 35              ''EVENT COUNTER
S X662 = 240000           ''MET CLOCK START
S X663 = 103              ''GN&C OPS 1 - MAJOR MODE 103 ____
S X666 = 103              ''CURRENT MAJOR MODE
S X642 = 240000           ''REFERENCE TIME FOR SIMULATION START
S X638 = 239998           ''START TIME FOR CONTINUOUS FUNCTIONS
S X639 = 239998           ''START TIME FOR TERMINATING FUNCTIONS
S X640 = 239998           ''COMM REG FOR COORDINATION START TIME
S X641 = 239998           ''START TIME USER INTERFACE FUNCTIONS
S X698 = 239998           ''START TIME FOR EVENT MASK GENERATION
S X643 = 2048             ''ALL EVENTS IN MM101 HAVE OCCURRED
S X644 = 512              ''ALL EVENTS IN MM102 HAVE OCCURRED
S X645 = 512              ''SET EVENT 35 - ET SEP MNVR COMPL
```

5.2.1 3 Cyclic Task Generation. To accommodate the NASA-unique cyclic dispatching of tasks, IMSIM was changed to incorporate this logic. The code for this logic is contained in section 5.2.1.7--NASA-unique IMSIM Revisions. It entails that once the Go/NoGo condition for a Principal Function (= task) was greater than 0, as determined by Variable 401, then cyclic task generation could take place.

Transactions for each of the Principal Functions (V409, V421) were generated, and the conditions for activation (V410, V411, and V421) and for termination (V412, V413, V422, V423) were tested When activated, the cyclic interval was determined (V415) for proper cyclic recurrence of task until terminating conditions were encountered Figure 5-3 depicts a block diagram of the activation logic.

The variables mentioned above are given in appendix A

Savex cells 568 and 577 were used as communication registers containing task number for functions in activation process

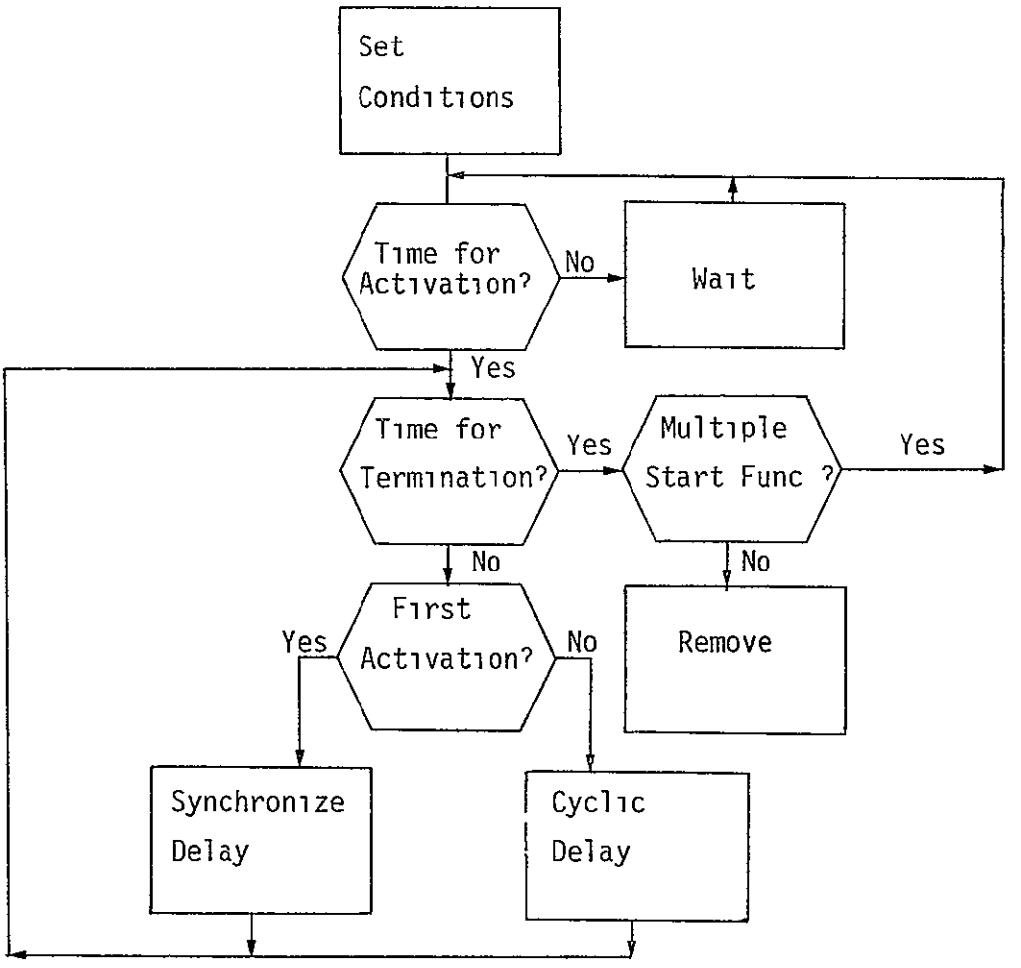

Figure 5-3 Principal Function Activation

The logic for this change is depicted in figure 5-4, giving the flow diagram for this logic; figure 5-5, giving the flow diagram for the continuous tasks and initial task generation logic, and figure 5-6, giving the flow diagram for the User Interface generation logic. Figure 5-7 depicts the logic for change of cyclic intervals for Principal Functions 1, 19, and 206 Reference 1, the MODLIT Reference Manual, details the symbols and code used in these flow diagrams

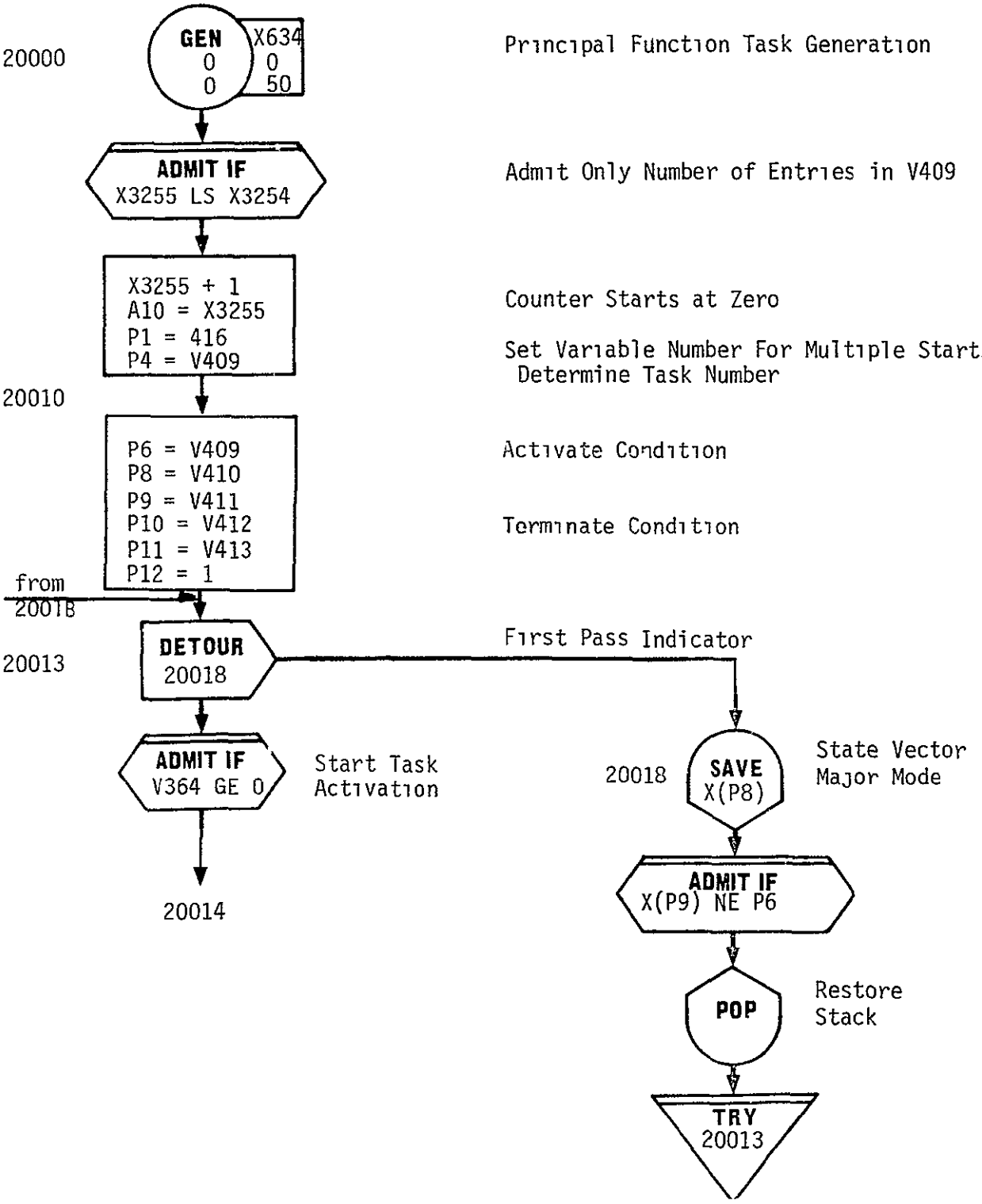

Figure 5-4 Cyclic Task Activation Logic

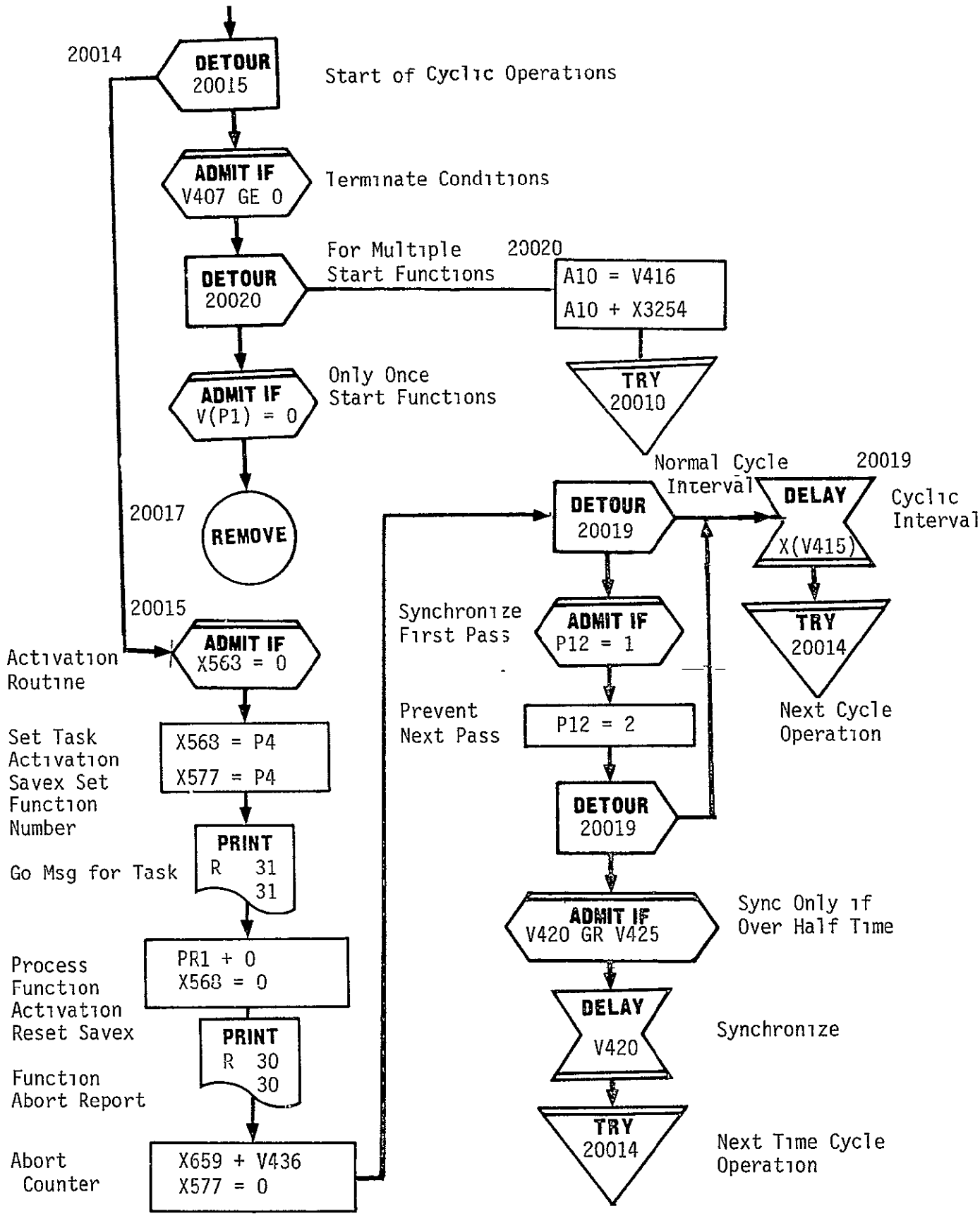

Figure 5-4 (cont)

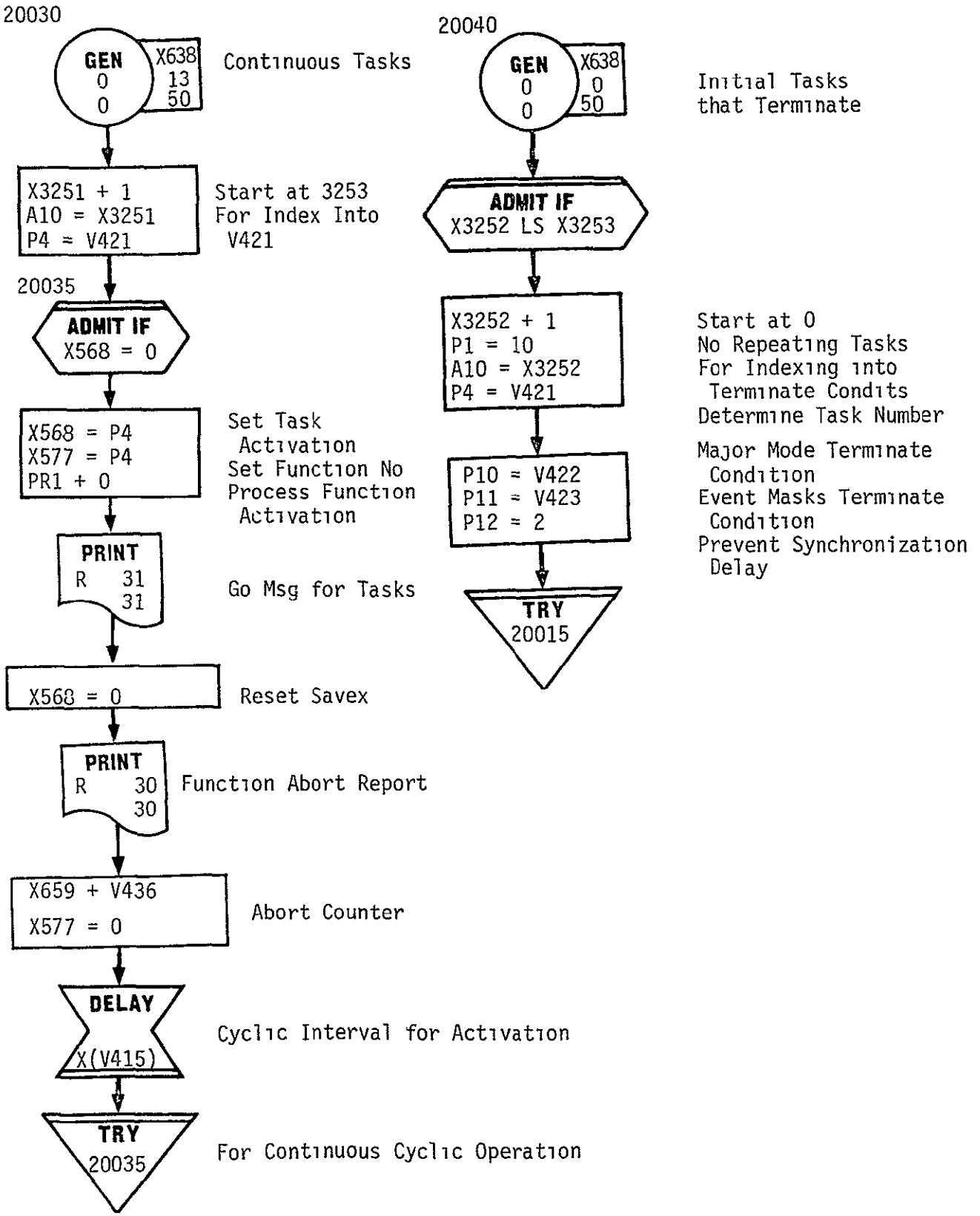

Figure 5-5. Continuous and Initial Task Generation

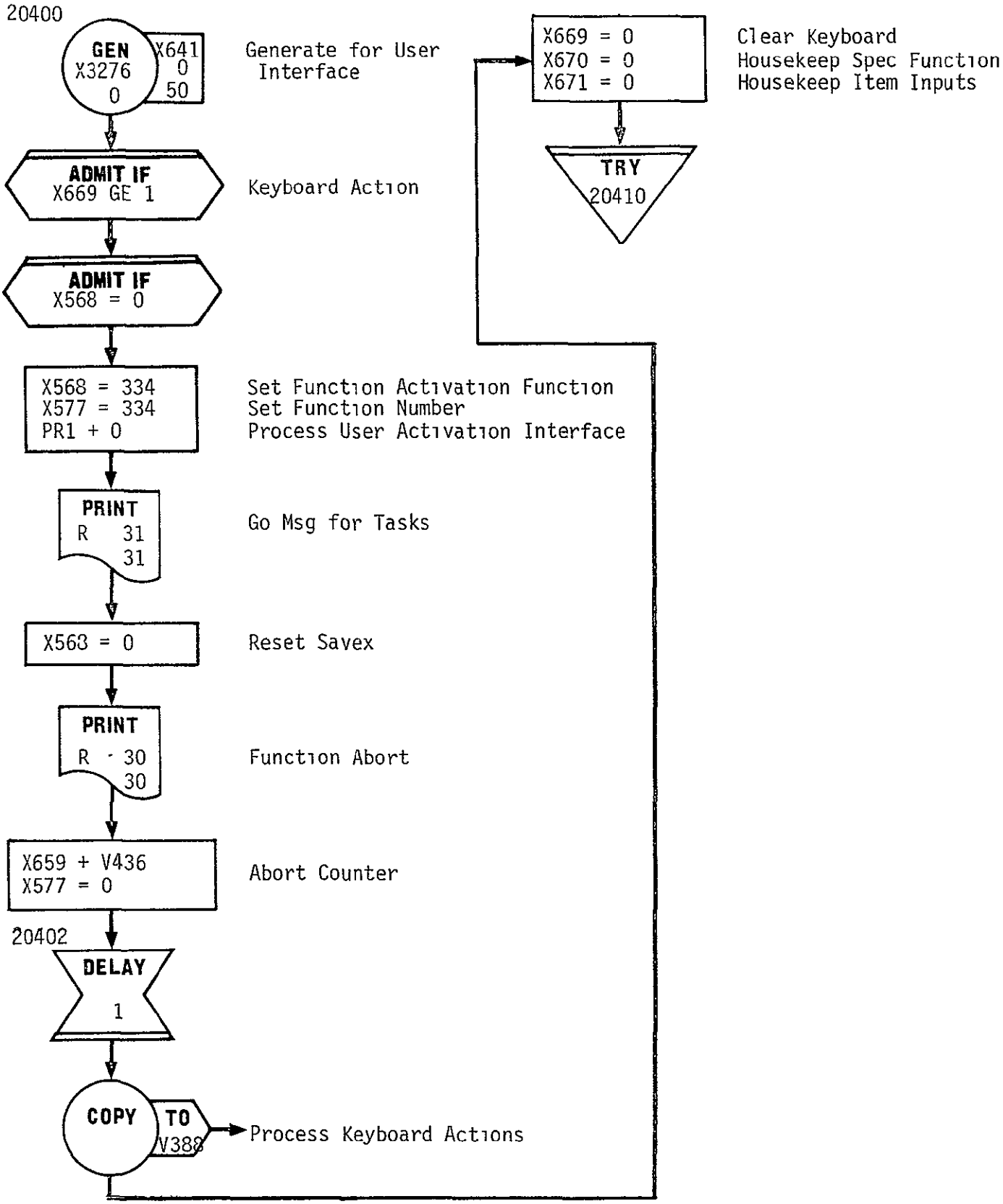

Figure 5-6 User Interface

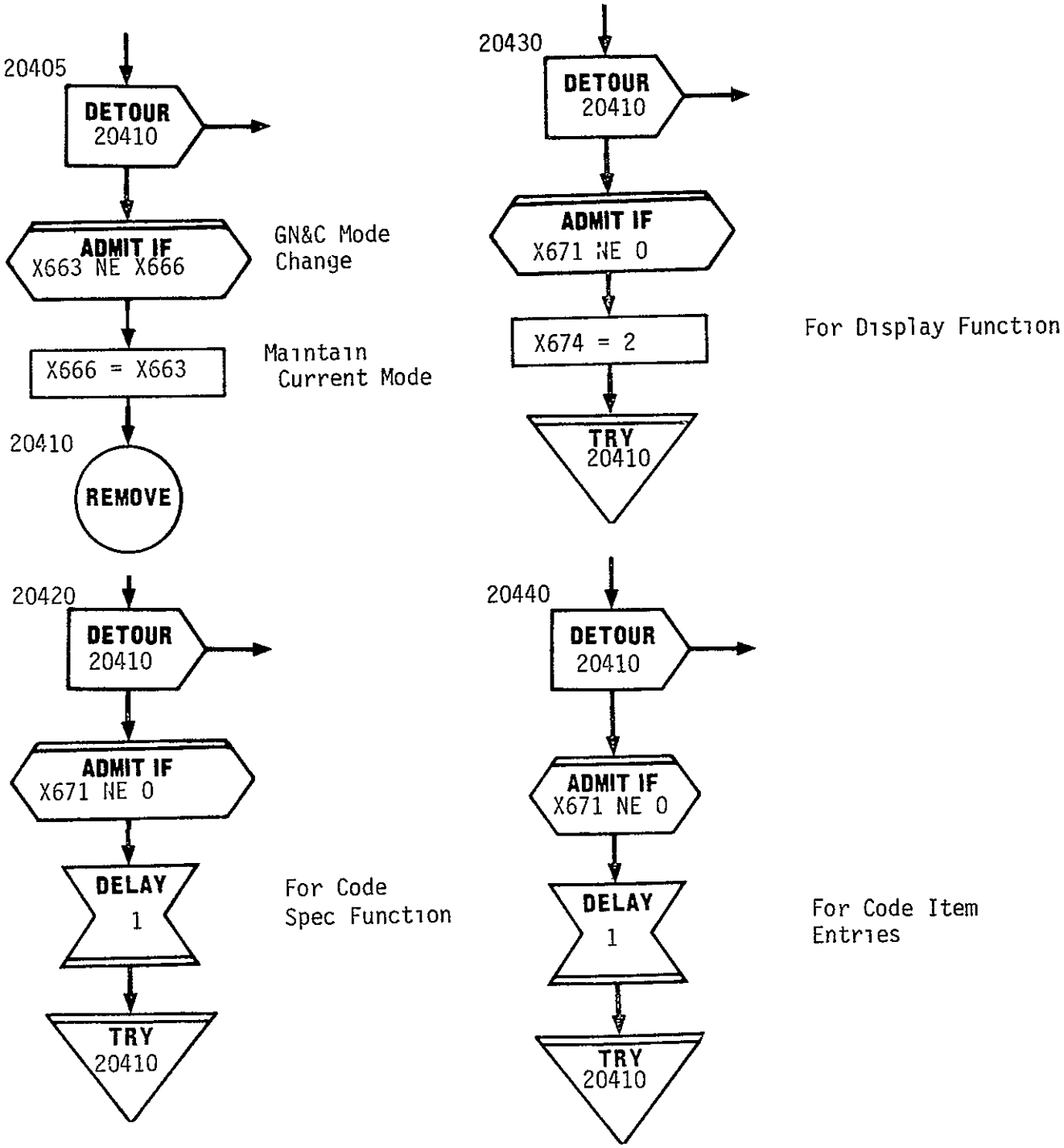

Figure 5-6 (cont)

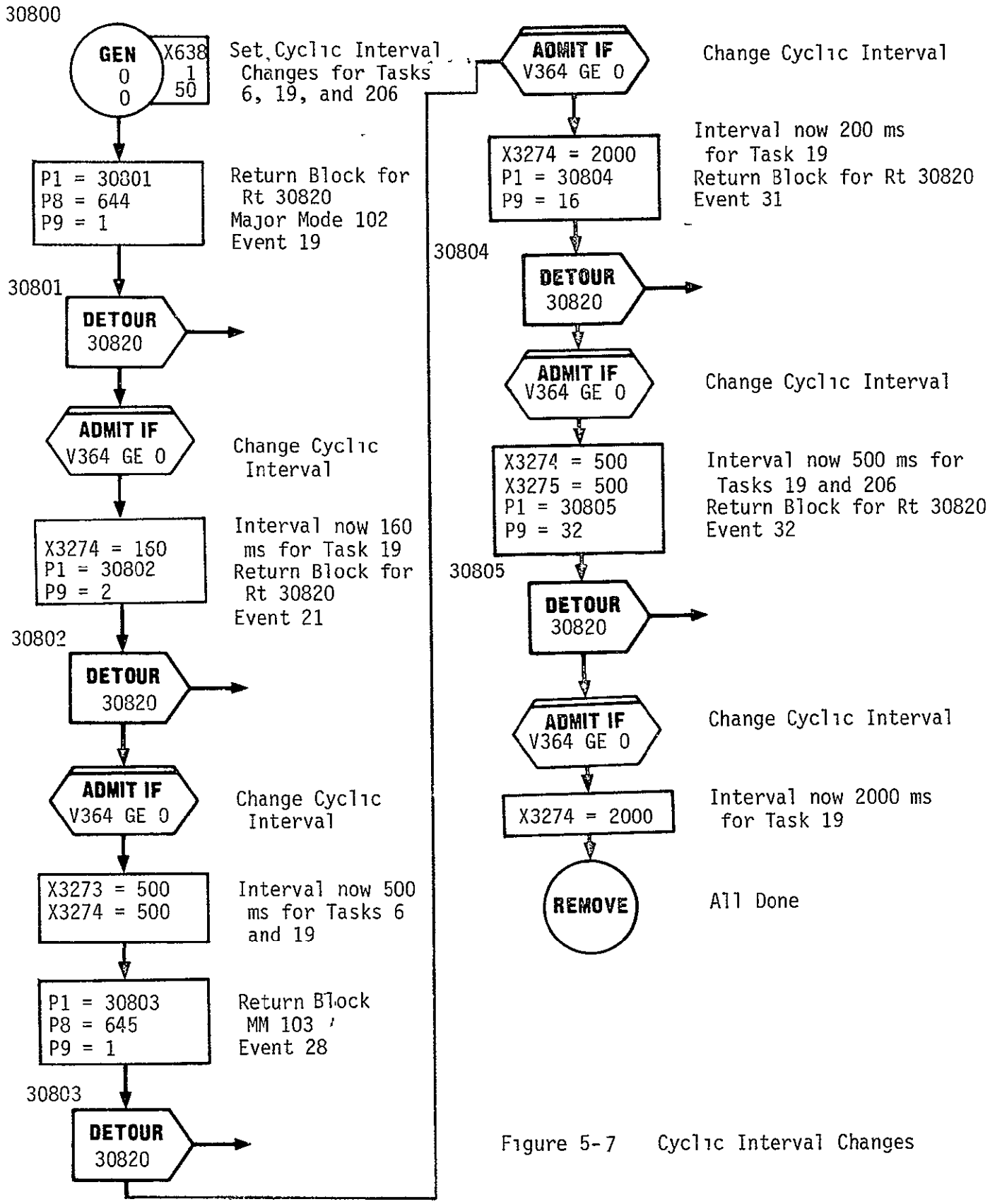

Figure 5-7 Cyclic Interval Changes

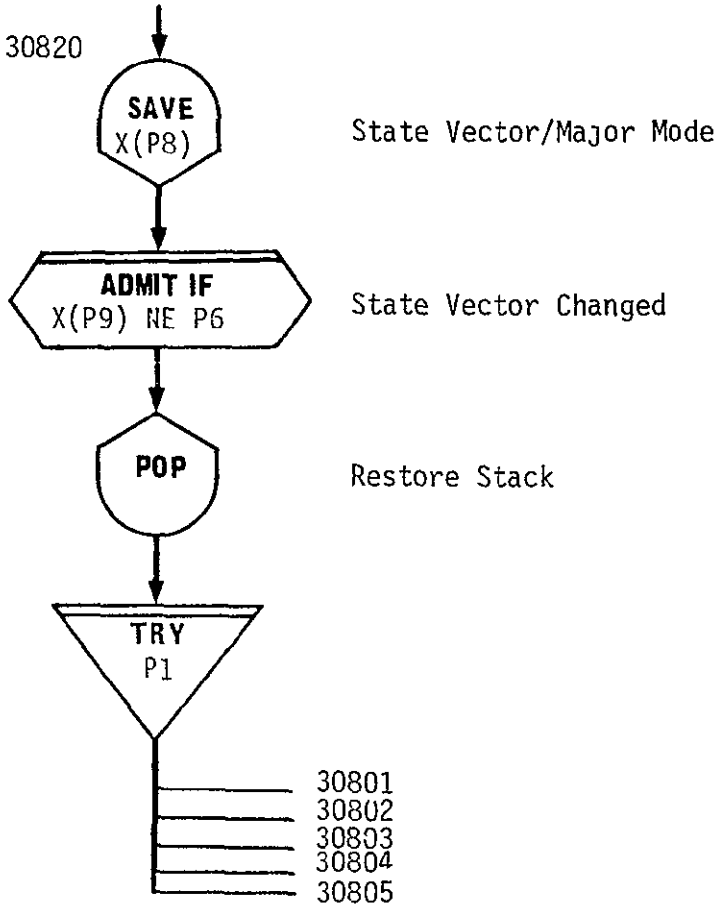

Figure 5-7 (cont)

The logic for the event generation and system state simulation, as described in section 5 1 4.4 is depicted in the flow diagram presented in figure 5-8, Event Mask Generation.

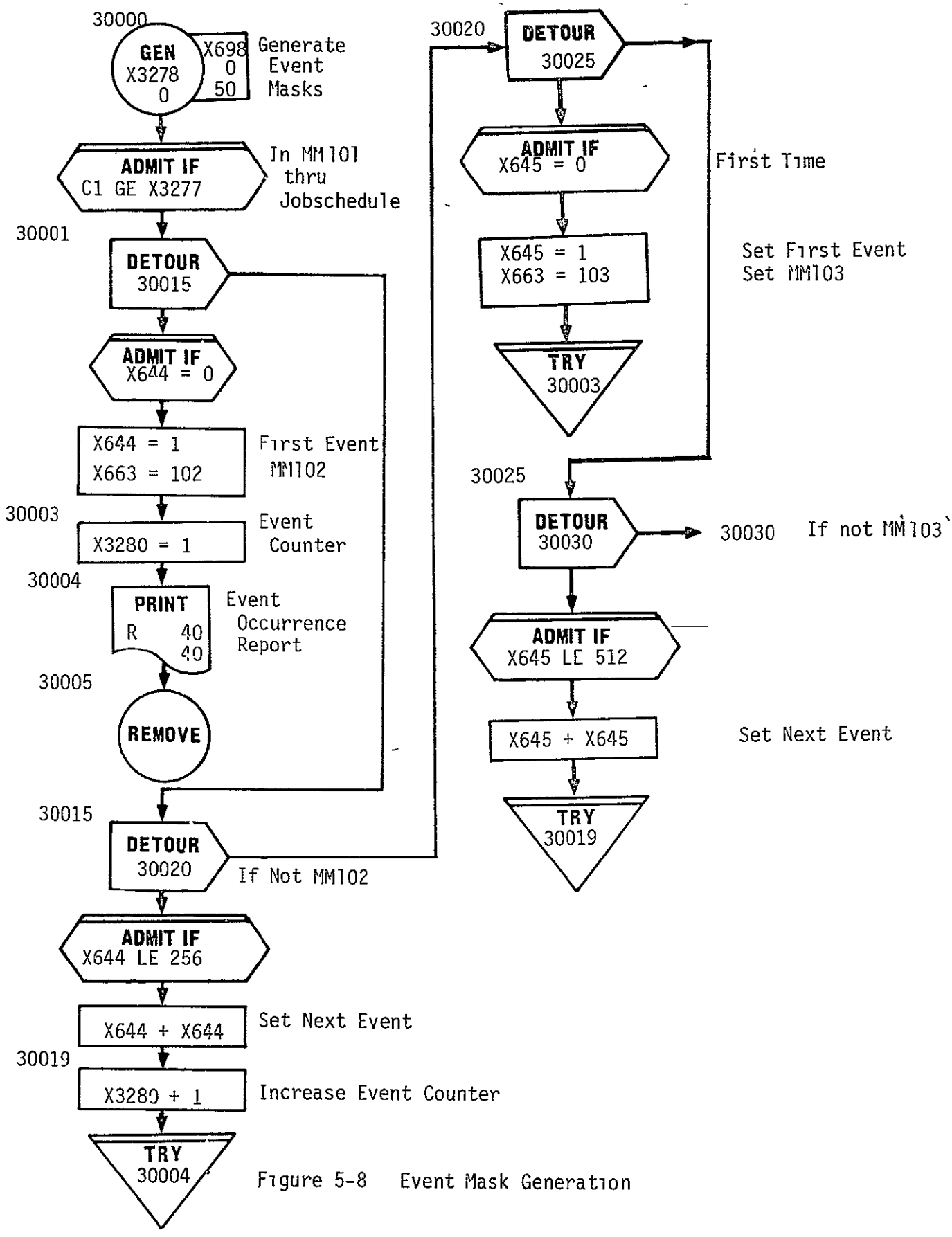

Figure 5-8 Event Mask Generation

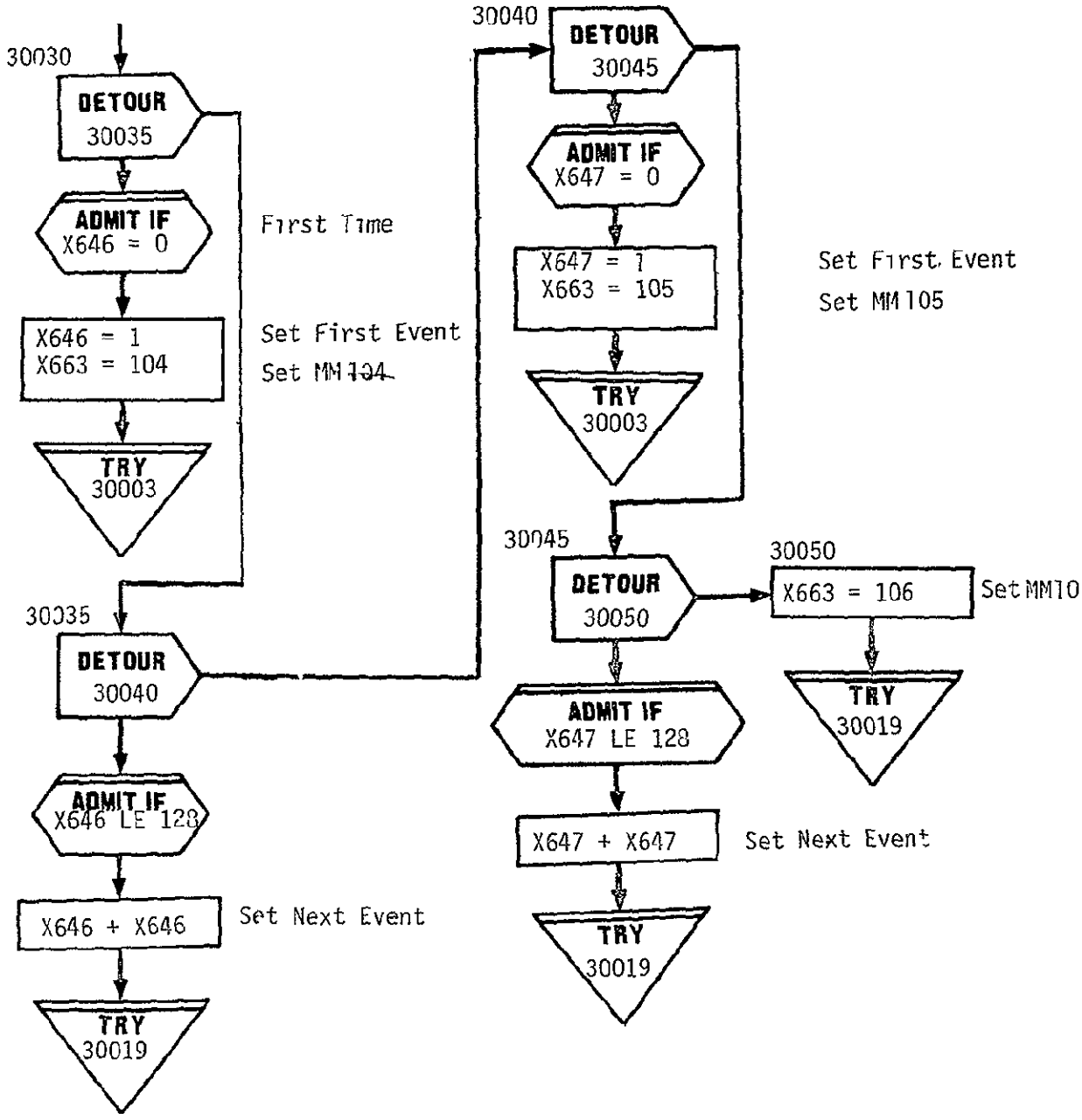

Figure 5-8 (cont)

5 2 1 4 Routine Computation Times The amount of compute time that is employed by a CPU for a given task is governed by one or more IMSIM routines that are associated with that task The associated routines are listed in the form 2 specifications. which delineate the routine and message environments for the defined tasks The routine specifications, in turn (IMSIM form 3) specify the amount of compute time "delivered" to the simulated CPUs for each invocation of each routine (each routine is called once per task execution) This is accomplished by MODLIT evaluating the "comp time variable" specified in form 3 for each routine at the time that routine is called

The following paragraphs discuss the mathematical variables so generated for these simulations, and present the amounts of equivalent delivered compute time for these routines, along with associated tasks and task frequencies. These equivalent comp times were obtained from a variety of sources Those routines which were virtually the same as equivalent routines employed in SDC's earlier simulations for ALT were extracted from the final report for that project (ref.4). Estimated comp times for new OFT routines were obtained by surveying appropriate FSSRs for GN&C (refs 6 through 12) and Computer Program Development Specifications (CPDSs) for OFT (refs 17 through 20) These estimating procedures utilized other appropriate documents that provided timing estimates for the CPU instruction set (refs 25, 26, and 30.)

These procedures resulted in voluminous amounts of working papers, the results of which are summarized in the following paragraphs. Details on the structure of the more extensive matrix variables appear in appendix A.

a Routine 11 - Selection Filtering - Variable 441

Executed by tasks 40, 41, 42, 45, 49, 120, 171, 193[T]

```
V441 = DFN (X(V107))(
 0.108      40
 0 072      42
 0 025      45
 0 312      49
 0 145     120
 0 240     171)
```

Each time this routine is called by one of these tasks, computation time is as follows

TASK	TASK FREQ	COMP TIME
40	40 ms, MM101 - MM106	0.225 ms
41	40 ms, MM102 and MM102	0 225 ms
42	40 ms, MM102 and MM102	0 150 ms
45	160 ms Fr evt34 in MM103 to evt36, MM104	0 052 ms
49	160 ms, MM101 through MM104 until evt43A	0.650 ms
120	40 ms, MM101 and MM102	0.302 ms
171	80 ms, starting at evt34 in MM103	0 500 ms
193	40 ms in MM102	0.500 ms

[T]For task descriptions, see appendix B

b Routine 13 - Ascent Navigation Sequencer Functions - Variable 325

Executed by task 15, Ascent Nav., every 4 seconds.

```
V325 = DFN(G(V299))(
  2.74        0
 0 025        1)
```

The computation time of this routine is a discrete function of the gate defined by variable 299 (task associated gate for initial execution). On the initial execution, the computational time is 5 7 ms. All subsequent executions are 0.052 ms

c. Routine 14 - Ascent/User Parameter Processing Sequence - Variable 326

Executed by task 197, Ascent User Param Proc Sequencer, every 2 seconds, starting at event 14, in MM101 through MM106.

```
V326 = DFN(X644)(
 0 015      0
 0 082      1
 0 010    128
 0 039    512)
```

The computation time for this routine is a discrete function of the system state in the major mode defined in Savex cell 644 Prior to SRB ignition, the computation time is 0.032 ms each time the routine is invoked With SRB ignition, computation time is increased to 0 171 ms. With the SRB separation sequence initiation, comp time is reduced to 0 021 ms At the SRB separation command, and for all subsequent executions, the comp time is 0.081 ms.

d Routine 45 - IMU Processing - Variable 356

Executed by task 309, Minor Cycle Exec, every 40 ms

```
V356 = 1.09 + (RF1) * 0 2
```

Each time this routine is called, comp time will be 2.271 ms plus a randomly selected value between 0 and 0.417 ms. Thus, comp time will vary from 2.271 to 2.688 ms for each call of routine 45.

e Routine 116 - System Software Interface - Variable 430

Executed by task 307, SSIP, every 40 ms.

V430 = V429 + 1 306
V429 = (1-X656'X45/(X656'X45))*X44 where X44 = 0.216
X45 = 10.000

Each time this routine is called, a total of 2.721 ms of comp time will be employed plus an amount of comp time that will vary as a function of the 40 ms counter The 2.721 ms will be employed every 40-ms cycle except for every 10th cycle (every 400 ms) when the comp time will be 3.171 ms.

f. Routine 136 - LDB Processing - Variable 16

Executed by task 333, LDB I/O Processor, every 40 ms during MM101

V16 = 0.384

Each time this routine is called, equivalent comp time will be 0.800 ms.

g Routine 148 - MCDS Input Processor - Variable 16

Executed by task 332, MCDS Input Processor, every 200 ms.

V16 = 0 180

Each time this routine is called, equivalent comp time will be 0.375 ms.

h Routine 149 - MCDS Message Processor - Variable 432

Executed by tasks 332, 333 (MCDS Input Processor, LDB I/O Processor). Task 332 executes every 200 ms, task 333 executes every 40 ms

V432 = DFN(X669)(
0.384 0
1.104 1)

The comp time of this routine will depend on the current GN&C major mode, which is set in Savex cell 669. When in null mode, this routine will have a comp time of 0.800 ms When in any other mode, 2 300 ms of comp time will result

I. Routine 156 - Maneuver Trim Display Support - Variable 16

Executed by task 8, Orbit Insertion Guidance, every 2 seconds during MM104 and guidance phase of MM105.

V16 = 0 600

Each time this routine is called, equivalent comp time will be 1.25 ms.

J. Routine 159 - Data Acquisition, Monitoring, and Feedback - Variable 446

Executed by numerous tasks as indicated below, where

V446 = DF(X(V107))(comp time/task matrix)

TASK	TASK FREQUENCY	COMP TIME
40	40 ms during MM101 through MM106	0 704 ms
41	40 ms during MM101 and MM102	0 423 ms
42	40 ms during MM101 and MM102	0.538 ms
49	160 ms during MM101 through MM104 until MSP dump complete	0 071 ms
52	40 ms, MM101 until MSP dump complete in MM104	0 342 ms
54	80 ms, evt 33 in MM103 through MM106	0 183 ms
65	40 ms, evt 33 in MM103 to evt 42A in MM104, evt 45 to evt 48A in MM105	0.375 ms
101	1 second	1.077 ms
102	1 second	1.775 ms
110	1 second	4.285 ms
119	40 ms, APUs on and slew chk cmd in MM101 until MPS dump complete in MM104	0.792 ms
120	40 ms in MM101, MM102	0 867 ms
180	80 ms in all major modes	1.023 ms
203	40 ms in MM101, MM102	1 000 ms
337	1 second	0.446 ms

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k. Routine 162 - Thrust Vector Control CMD SOP - Variable 346

Executed by tasks 60, 62, and 64

V346 = DFN(X(V107))(comp time/task number matrix values)

The computation time for this routine is a discrete function of the task which executes it.

When executed by task 60 (MPS Thrust Vector Control Command SOP-MTUP), the computation time is 1 060 ms. Frequency is 40 ms, MM101 through MM104.

When executed by task 62 (SRB Thrust Vector Control Command SOP-STVP), the computation time is 0 780 ms Frequency is 40 ms, MM101 and MM102

When executed by Task 64 (OMS Thrust Vector Control Command SOP-OTVP), the computation time is 0.381 ms Frequency is 40 ms, portions of MM103-MM105.

l. Routine 163 - Aerosurface Actuator CMD SOP - Variable 337

Executed by task 50, Aerosurface Actuator Cmd SOP, every 40 ms during MM101 through MM104 until MPS dump.

V337 = X44 + RF1 * 0 025, where X44 = 0.615

Each time this routine is called by task 50, V337 generates 1 281 ms of computing units plus a random fraction varying between 0 and 0.052 ms, for an overall range of 1 275 to 1.327 ms

m Routine 166 - IMU Redundancy Mgt - Variable 16

Executed by task 309, 319 (minor cycle exec - every 40 ms, IMU major cycle exec - every 320 ms)

V16 = X44, where X44 = 0 140

Each time this routine is called, equivalent comp time will be 0.292 ms

n Routine 170 - RCS Command Generation - Variable 327

Executed by task 201, Insertion Digital Autopilot, every 40 ms from evt 34 in MM103 through MM106.

```
V327 = DFN(X663)(
 0.072    100
 0 485    500)
```

These computation times are discrete functions of Savex cell 663, which defines the GN&C major modes and ops For normal ascent operation, computation time will be 0 150 ms whenever this routine is called For abort operations, the comp time is 1 01 ms.

o. Routine 171 - Compute Steering CMDS - Variable 328

Executed by tasks 6, 7, and 8.

V328 = DFN (X(V107))(matrix values)

The computation times for routine 171 are discrete functions of the tasks requiring its execution

In task 6, for R/S Auto Seq Start, the computation time is 3.415 ms In task 7, for Force Override SRBACT, the computation time is 15.600 ms In task 8, for SRB FCS/HYD Verification, the computation time is 13.600 ms.
Task 6 frequency is 160 ms at SRB ignition in MM102, 500 ms after evt 21
Task 7 frequency is 2 seconds from start of MM103 until evt 32.
Task 8 frequency is 2 seconds during MM104 and guidance phase of MM105.

p Routine 176 - Redundant Set Launch Processing Sequence - Variable 341

Executed by task 114, RSLS, every 80 ms, during MM101

V341 = 0 3 - X661$15*0 3 + 0 1*(X643$2048-X643#1024)

The computation time for this routine is 0.625 ms plus or minus factors which are functions of the value of the countdown clock and the value of the event mask for MM101. Comp time will be 0 at T-20 to T-15, and 0 625 ms from T-15 to the occurrence of event 17 (SSME start), at which time the compute time will be reduced to 0.417 ms.

q Routine 177 - Sequencers - Variable 340

Executed by tasks 70, 115, 116, 161, 164.

V340 = (RF1*(V338-V339) + V339)*0 48

The computation time for this routine is task dependent, and, for every associated task, varies randomly between a minimum and maximum value for each iteration of that task. Computation times are as follows

TASK	TASK FREQ†	MINIMUM COMP TIME	MAXIMUM COMP TIME
70	160 ms	0.070	0.540 ms
115	40 ms	0 320	0 614 ms
116	40 ms	0.030	0.460 ms
161	160 ms	0.287	0.287 ms
164	40 ms	0 050	0.250 ms

r Routine 181 - Main Engine SOP - Variable 16

Executed by task 181, SSME SOP, every 40 ms until MPS dump complete (evt 43A) in MM104.

V16 = X44, where X44 = 0.230

Each time this routine is called, computation time will be 0.470 ms This will occur whenever the SSME SOP principle function is processed (every 40 ms)

s Routine 183 - Flight Control Reconfiguration - Variable 329

Executed by tasks 176, 201, at 40 ms intervals.

V329 = DFN(G(V299)X663)(matrix values)

The computation time of this routine varies from 0.150 ms to 0.390 ms, depending on the major mode (101, 102, or 103) and the associated task. On initial execution of the Terminal Count, the computation time is 0.230 ms For all subsequenct executions, the computation time is 0.150 ms. On the initial execution of First Stage (of ascent operation), the computation time is 0 280 ms For all subsequent executions, the computation time is 0 200 ms. On the initial execution of Second Stage (of ascent operations) the computation time is 0.390 ms. For subsequent execution, the computation time is 0 310 ms.

†See task descriptions for details on associated modes and events.

t Routine 185 - OMS Firing Sequence - Variable 342

Executed by task 182, OMS Firing Sequencer, at 40 ms intervals.

V342 = DFN(V403 X678 X685)(matrix values)

The computation time associated with this routine varies from 0.013 ms to 1.273 ms each time the routine is called, depending on

1 the OMS firing sequence ops,
2. the OMS fuel valve positioning status;
3 the OMS failure status flag.

u. Routine 186 - OMS to OMS Interconnect Function - Variable 16

Executed by task 183, OMS to OMS Interconnect, at 160 ms intervals, in portions of MM104, MM105.

V16 = X44, where X44 = 0 279

Each time this routine is called, a computation time of 0.581 ms will result.

v Routine 188 - SRB Actuator Slew Check - Variable 16

Executed by task 188, SRB Actuator Slew Check, at 40 ms intervals in portions of MM101.

V16 = X44, where X44 = 0.384.

Each time this routine is called, a computation time of 0.800 ms will result

w. Routine 202 - Command Processing - Variable 330

Executed by task 176, Ascent Digital Autopilot, called every 40 ms (However, this routine is only executed every other 40 ms cycle, as shown below)

V330 = FDN (V366 X663)(matrix values)

Routine 202 contains two principal subroutines to perform its command processing function. For the Solid Rocket Booster commands, the following processing functions are performed
Trim Mixing Logic Computation,
Chamber Pressure Parameter Calculation,
Thrust Vector Deflection and Actuator Limit Processing, and
Thrust Vector Deflection and Actuation Limiting Calculation.

For the Orbiter commands, the following processing functions are performed:
Trim Mix Nozzle Deflection Computation,
Bias Computation, Strobe, and Rate Limits,
Priority Rate Limitation Calculation for Strobe, and
Actuator Commands Computation.

The computation time of Routine 202 is a discrete function of Variable 366 which is an 80 ms time-slice counter, and of the Major Mode from which it is executed by task 176

During MM101, the computation times are 6 396 ms and 6 875 ms, alternating every 80 ms.

During MM102, the computation times are 7 600 ms and 8 070 ms, alternating every 80 ms

During MM103, the computation time is 2 500 ms each time the routine is executed, regardless of the 80 ms counter setting.

x Routine 203 - Thrust Vector Control Laws - Variable 331

Executed by tasks 176, 201, every 40 ms, in various segments of MM101 through MM106.

V331 = DFN (X663 X672)(matrix values)

Routine 203 performs computations for the following seven functions when executed by tasks 176 and 201:
Roll Thrust Vector Deflection Command
Pitch Thrust Vector Deflection Commands
Stage 1 Pitch Rate Feedback Error
Stage 2 Pitch Rate Feedback Error
Yaw Thrust Vector Deflection
Stage 1 Yaw Rate Feedback Error
Stage 2 Yaw Rate Feedback Error.

The computation time of this routine is a discrete function of the navigational state defined in Savex cell 672, and of the setting of Savex cell 663, which indicates the GN&C major modes and ops. In the Terminal Count, no computation time is used.
During First Stage operations, when in autotrim mode, the computation time is 8 45 ms When in manual mode, the computation time is 8 13 ms
During Second Stage operations, when in autotrim mode, the computation time is 3 91 ms. When in the manual mode, the computation time is 3.75 ms
During OMS 1, Insertion (autotrim mode only is used), the computation time is 2 85 ms

y Routine 204 - Linear Interpolation Functions - Variable 332

Executed by tasks 36, 176, 201, every 40 ms.

V332 = DFN (X687 X663)(matrix values)

Routine 204 performs the following functions when executed by tasks 36, 176, and 201
Relative Velocity Extrapolation Calculation,
Stage 1 Trim and Acceleration Calculation,
Stage 2 Trim Calculation,
Scheduled Elevon Deflection Computation, and Thrust Vector Control Gains Calculation.

The computation times for the execution of this routine are discrete functions of the state of the vehicle safing Savex (X687), and of the setting of Savex cell 663 (GN&C major modes and ops).
Prior to ascent operations, the computation time is 0.150 ms.
During First Stage Operations, under normal conditions, the computation time is 4.870 ms, and with SSME cut, the computation time is 14.890 ms
During Second Stage operations, under normal conditions, the computation time is 4.250 ms , and with SSME cut, the computation time is 9 700 ms
During OMS 1 Insertion both under normal conditions and with SSME cut, the computation time is 2 500 ms

z Routine 206 - G&C Steering Interface - Variable 440

Executed by task 175, G&C Steering interface, every 40 ms in MM102 through MM106.

V440 = V347 + V348 + V349 + 0.329

This routine employs a constant 0 684 ms for attitude errors computations every 40 ms, plus terms for the following

ROUTINE	FREQ	COMP TIME RANGE
DBCMDS S2G	480 ms (Stage 2 only)	8.416 - 12.292 ms
DBACCEL	480 ms	4.500 - 5.343 ms
DBQUAT	40 ms	0.912 - 2.038 ms

Thus, computation time can be as low as 1 596 ms at most 40 ms intervals to as high as 20.357 ms at some 480 ms intervals

(NOTE The 0 684 ms for error computations may not be required every cycle)

aa. Routine 207 - Aerosurface Control Functions - Variable 333

Executed by tasks 36 and 176.

V333 = DFN(X688 X663)(matrix values)

Routine 207 performs the following function when it is executed by tasks 36 and 176.
Body Flap Deadband/Hysteresis Computation (every 160 ms),
Elevon Load Relief Calculation (every 80 ms), and
Elevon Load Relief Subroutine 2X (every 80 ms).

The computation time of the routine is a discrete function of the GN&C major mode and ops, as well as the status of the 40 ms counter, and generates computation time as follows

FREQ	MODE	COMP TIME
80 ms	101	2 110 ms
80 ms	103	0 042 ms
160 ms	101	1 950 ms
160 ms	103	0.042 ms

bb Routine 210 - Attitude Processing Functions - Variable 343

Executed by task 97, Attitude Processing, every 40 ms, all major modes.

V343 = DFN(X657 G(V299))(matrix values)

This routine utilizes the status of the task-associated gate (G(V299)) and the status of the 40 ms time-slice counter (X656) Computations are performed for.

Attitude processing initialization	- initial cycle only
Attitude mode change	- initial cycle only
Outer loop precision	- 960 ms
Inner loop quaternion update	- 40 ms
Attitude display	- 40 ms

Resultant computation times are 3 500 ms on the initial cycle, 0 900 ms every 40 ms, and 4.000 ms every 960 ms.

cc Routine 211 - Rotational Hand Controller Processing Functions - Variable 16

Executed by task 171, three-axis RHC SOP, every 80 ms starting at evt 34.

V16 = X44, where X44 = 0.200

This routine will employ 0.417 ms of computation time whenever called. This time will include subroutines for RHC subsystem ops program initiation, RHC compensation calculations, RHC deadbanding computation, and RHC station select calculations.

dd. Routine 212 - Ascent User Parameter Processing - Variable 334

Executed by task 19, Ascent User Parameter Processing. Rates vary from 160 ms to 2000 ms, depending on current mode and event

V334 = DFN (X663)(matrix values)

This routine is controlled by the Ascent User Parameter Processing Sequencer routine, and includes subroutines for guidance-related computations, ascent dynamic pressure computations, and displays computations. Computation times are discrete functions of the state of the major mode, as follows.

MAJOR MODE	COMP TIME
101	0.181 ms
102	2.104 ms
103	0 250 ms
104	0.025 ms

ee Routine 213 - Body Flap Command FDIR - Variable 16

Executed by task 95, Body Flap Command FDIR, every 320 ms during MM101 through MM104 until MPS dump complete

V16 = X44, where X44 = 0 040

Each time this routine is called, resultant computation time is 0.083 ms.

ff Routine 214 - Fault Detection and Isolation - Variable 344

Executed by tasks 91, 92, every 40 ms

V344 = DFN(X(V107) X690)(matrix values)

Routine 214 performs the following calculations for tasks 91 and 92.
Available Jet Status,
Jet Failure Monitor (2 subroutines),
Jet Leakage Monitor,
Manifold Status Monitor, and
Jet Fault Limit

The computation time for routine 214 is a discrete function of the task which executes it, and of the status of the faulty thruster indicator (Savex X690) When executed by task 91 (Reaction Control System FDI-RCSF), the computation time under normal conditions is 1.375 ms and with the faulty thruster indicator set it is 2 17 ms. When executed by task 92 (Orbital Maneuvering System FDI-OMSF), the computation time under normal conditions is 0 188 ms , and with the faulty thruster indicator set, it is 0 292 ms.

gg Routine 215 - Ascent Navigation - Variable 335

Executed by task 15, Ascent Nav, every 4 seconds

V335 = (1.73+(1-RF1/1 2)*360 +(1-RF2/1 4)*40 8)*0 48 + V351
V351 = (1-RF3/0 5) * 4 18 * 0 48

Task 15 is executed at 4-second intervals at start of Nav Initiation (event 14) in MM101 through MM106 Maximum operating times for the subroutines that make up this function are assumed to be as follows

1 Nav ascent control - 0.120 ms
2 Nav state vector propagation - 360 ms
3 Covariance matrix propagation - 40 8 ms
4 Manual state and covariance setup - 4 2 ms
5. Storage of final paramters - 1.61 ms

Assumptions that were made in arriving at the above variable expressions were as follows·

1 All of the nav ascent control and parameter storage computation time (a total of 1.73 ms) would be required every 4-second iteration
2. Nav state propagation computations (maximum of 360 ms of computation time per 4000 ms) would occur approximately 58% of the time

3 Covariance matrix propagation computations (maximum of 40.8 ms of compuation time per 4000 ms) would occur approximately 64% of the time.

4. Manual state and covariance setup (maximum of 4.2 ms of computation time per 4000 ms) would occur approximately 50% of the time.

Thus, over a 4-second cycle, computation time should average out to

1.73 + 0 58 X 360 + 0 64 X 40.8 + 0 5 X 4.2 $\approx$ 239 ms,
Minimum and maximum values would be $\approx$ 69 ms and 407 ms, resp.

Since this routine has a considerably larger computation time than other routines, assumptions and approaches that were used in estimating the computation times of the five subroutines listed above are presented below All estimates are based on the preliminary design specs contained in RI document SD-76-SH-0004A, Space Shuttle OFT Level C Functional Subsystem Software Requirements Document (FSSR), Guidance, Navigation, and Control - Part B - Navigation, September 1976, pp. 4 3 1-1 through 4 3 1-18 and pp B 2 1-1 through B2.1-24.

1. Nav Ascent Control

ACTIVITY	INSTRUCTIONS	NET
a) SNAP IMU	10 reads & saves @ 2 µs	20 µs
b) Call NAVSTATE PROP	10 load inst @ 1.4 µs	14 µs
c) Call COVEXTRAP PF	10 load inst @ 1.4 µs	14 µs
d) Call MAN STATE + COV SETUP	10 load inst @ 1.4 µs	14 µs
e) Call THREE STATE TO ONE STATE	10 load inst @ 1 4 µs	14 µs
f) Save related data	20 reads & saves @ 2 µs	40 µs
		116 µs
		or $\approx$ 0 120 ms

2. State Vector Propagation

ACTIVITY	INSTRUCTIONS/EXECUTION TIME	NET
a) Compute time tag differences	3 subtractions @ 3.0 μs	9.0 μs
b) Call Super G Nav (3 times, 6 Components each)	→ (18.560+1.440 ms overhead) X 18	360 ms
↓		
Call ACCEL (2 times each call)	→ 9.280 msX2 = 18.560 ms	
↓		
Call ACCEL EARTH GRAV CODE	- 2000 μs	
ACCEL ATTITUDE CODE	- 3130 μs	
ACCEL VENT & THRUST CODE	- 1900 μs	
DENSITY CODE	- 850 μs	
ACCEL DRAG CODE	- 1400 μs	
	9280 μs →	
c) Save current time tag for next cycle	3 ops @ 2 μs	6 μs
		≈360 ms

Associated assumptions were as follows

1) Integration of PV equations of motion are performed separately for each of 3 state vectors @ 6 parameters/state vector.
2) The SNAP IMU function has already been performed by the NAV Ascent Control Subroutine.
3) For the ACCEL function, the ACCEL ATTITUDE CODE, the ACCEL VENT AND THRUST CODE, the DENSITY CODE, and the ACCEL DRAG CODE must all be executed
4) Density calculations assume the vehicle altitude is within zone 2
5) LVLH and IWR code are both executed by the ACCEL ATTITUDE code
6) The ACCEL VENT AND THRUST CODE is performed for five iterations each time it is called

3 Covariance Matrix Propagation

ACTIVITY	INSTRUCTIONS	NET
a) Vector selection	100 ops @ 8 μs each	800 μs
b) Gravity gradient	200 ops @ 20 μs each	4000 μs
c) Matrix propagation	3000 ops @ 12 μs each	36000 μs
		40 8 ms

Assumptions:
1) Gravity gradient operations are performed on a 3 x 3 matrix
2) Matrix propagation operations are performed on a 12 x 12 matrix

4. Manual State and Covariance Setup†

ACTIVITY	INSTRUCTIONS	NET
a) vector selection	100 ops @ 8 μs each	80 μs
b) parameter setup	100 ops @ 8 μs each, 50 ops @ 3 μs each	950 μs
c) covariance initialization and flag set	400 ops @ 6 μs each, 15 ops @ 2 μs each	2430 μs
		≈ 4.2 ms

5 Storage of Final Parameters

ACTIVITY	INSTRUCTIONS	NET
a) reductions to single state parameters (vector selection ops)	150 ops @ 8 μs each	1200 μs
b) storage of selected parameters	4 ops @ 2 μs each	8 μs
c) retention of current filter state vector and setting of filter update flag	100 ops @ 4 μs each	400 μs
		≈ 1 6 ms

hh Routine 216 - Main Engine Operations - Variable 336

Executed by task 165, SSME ops, every 40 ms in MM102 and MM103 until ET sep cmd

```
V336 = DFN (X687)(
  0 288     0
  0.770     1)
```

The computation time of this routine is a discrete function of the vehicle safing flag in Savex cell 687. Under normal operations, computation time is 0.600 ms If an SSME is out, computation time will be 1 600 ms

†Performed only during ascent coast phases, as required

ii. Routine 218 = Ascent RCS Processing - Variable 345

Executed by task 190, Ascent RCS Cmd SOP, every 40 ms from evt 32 in MM103 through MM106

V345 = 0.740 - X645$256 * 0.160 + X645$512 * 0.320

This routine provides a computation time of 1.542 ms plus or minus quantities which are functions of the MM103 event mask flags. If event 34 occurs, compute time is reduced by 0 333 ms to 1.209 ms. If event 35 occurs, computation time goes back to 1.542 ms.

JJ. Routine 219 - Aerojet Digital Autopilot - Variable 405

Called by task 36, Aerojet Digital Autopilot, every 40 ms in MM103 from evt 32 to evt 34.

V405 = X44 + X 656'2 * X45, where X44 = 2 340
X45 = 0 290

This routine includes computations for the following

SUBROUTINE	FREQ	COMP TIME
Reconfiguration	80 ms	0.605 ms
Priority rate limiting	40 ms	0 495 ms
Bank channel	40 ms	2 975 ms
Pitch channel	40 ms	1 390 ms

Computation time will thus be 4 860 ms every other 80 ms cycle, and will be 5 465 ms on alternate 80 ms cycles

kk Routine 220 - Throttle Control Functions - Variable 449

Executed by task 181, SSME SOP, called every 80 ms However, this routine will execute every other 40 ms cycle.

V449 = X656'4 * 0 01 - X656'4$2 * 0 02 + X656'4$3 * 0 02

This routine is called every 80 ms during S2G. On alternate 80 ms cycles, the computation time will be either 0 060 ms (with SLOWFLAG on) or 0.012 ms (with SLOWFLAG off)

11. Routine 221 - GN&C Display Processing - Variable 448

Executed by tasks 206, 210, every 2 seconds or 500 ms, depending on task, mode, and event status.

V448 = DFN (X(V107) G 5210 X647)(matrix values)

Under task 206, this routine will prepare data for LAUNCH TRAJ 1 from event 1 to event 28, and for ASCENT TRAJ 2 from event 28 to event 36. Under task 210, data will be prepared for OMS 1 MVR EXEC from event 36 to event 50

Task 206 comp time is 0.208 ms Task 210 comp times will be 1.250 ms on its initial iternation and 0 500 ms on all subsequent iterations, except when event 49 is reached, after which comp time will drop to 0.100 ms.

mm Routine 301 - Flight Control/Fast Cycle Executive - Variable 350

Executed by task 306, Fast Cycle Exec, every 40 ms

V350 = X44 + (X669 - X669$2 - X669$3 +X669$4*4 - X669$5)*0.015 + V352

where X44 = 0.025 and
V352 = (X669$6 - X669$7 - X669$8*8 - X669$9) * 0.015

Computation times for almost all defined components of the FCE are distributed among the other principal functions The one activity that is specifically included within the FCE is Keyboard Interface Processing Thus, the expressions described above employ the Keyboard and Applications Control status matrix (Savex cell 669) to generate appropriate computing units These result in a value of 0.050 ms plus various terms, depending on the status of that matrix. Resultant computation times will be as follows

KIP MODE	COMP TIME
00	0.050 ms
01	0 080 ms
02	0 080 ms
03	0.080 ms
04	0.200 ms
05	0.200 ms
06	0.200 ms
07	0 200 ms
08	0 080 ms
09 etc	0

nn. Routine 303 - IMU BITE Processing Accelerometer Accumulator and Gyro Torquing - Variable 362

Executed by task 309, Minor Cycle Exec, every 40 ms.

V362 = (0.560 + RF1 * 0.030) * 0 480

The computation time of this routine is randomly variable from 0.560 to 0.590 ms for each call of this routine.

oo Routine 304 - Displays and IMU Moding - Variable 390

Executed by task 168, Ascent Attitude Director Indicator Processor, every 160 ms for processing and every 960 ms for switches, starting at evt 14.

V390 = (0 09 + V391) * 0.480
V391 = 0 01 + X674 * 0.380

The computation time for this routine will vary from 0 100 ms to 0.860 ms, depending on the display status flag, as follows·

DISPLAY STATUS	COMP TIME
current display	0 100 ms
current display update	0.480 ms
new display	0 860 ms

pp Routine 305 - IMU Gyro and Accelerometer Functions - Variable 16

Executed by task 319, IMU Major Cycle Exec, every 320 ms

V16 = X44, where X44 = 1.344

Each time this routine is called, computation time will be 2 800 ms

qq Routine 306 - Navigation - Variable 368

Executed by task 45, Radar Altimeter SOP, every 160 ms from evt 34 to evt 36

V368 = (X44 + V369) * 0 48 where X44 = 0 150
V369 = DFN (X663)(matrix values)

Computation time for V368 consists of a fixed value of 0.150 ms (stored in Savex cell X44) and a value which is a discrete function of the Major operational mode. The times for V369 are as follows:

- 0.300 ms for Null and Preflight Prep Modes
- 0 340 ms for all other modes except TAEM
- 0.160 ms for TAEM and subsequent modes

Computation time will therefore range between 0 310 ms and 0 490 ms

rr. Routine 309 - IMU Major Functions - Variable 353

Executed by task 319, IMU Major Cycle Exec, every 320 ms.

```
V353 = DFN (X663)(
   2.880    0
   2 544  100)
```

The computation time for Variable V353 is a discrete function of the state of the Major Mode, as defined by the state of Savex cell 663 For NULL and Preflight Prep, the computation time is 6.000 ms. For all other major modes, the computation time is 5.300 ms

ss Routine 313 - User Interface Supervisor - Variable 431

Executed by task 334, User Interface Control, on demand

V431 = DFN (X669)(matrix values)

The computation time for this routine is a function of the keyboard and applications control flag, as contained in Savex cell 669 Computation time will range from 0.417 ms (msg reset state) to 5.229 ms (display state).

tt Routine 314 - Cyclic Display Processing - Variable 435

Executed by task 335, Cyclic Display Processing, every 100 ms.

V435 = X44 * 3 + X45 * X674 where X44 = 2 060
X45 = 8 300

Computation time will be equal to 12 875 ms plus a factor that is a function of the display flag status Computation time will be as follows

DISPLAY FLAG	TOTAL COMP TIME
CURRENT DISPLAY	12 875 ms
CURRENT DISPLAY UPDATE	30.167 ms
NEW DISPLAY	47.458 ms

For these runs, only the Current Display option has been employed. The other options cannot be called by SPEC functions during the Ascent phase

5 2 1 5 Data Message Sources, Sinks, Length and Interval. The following group of variables are used to define the sources, sinks, length, and intervals of the messages transmitted in the NASA simulation runs

a Sinks for LL and LR messages (Message 44)

The LL and LR MDMs have Device numbers 60030, 60031, 60032, and 60033. Message transmissions are routed to these devices using V354 as the message sink.

V354 = P8 + 60029

where
P8 = Number of transmissions remaining for the message
60039 = Device number used as the base for identifying the devices to which transmissions are to be sent.

Message 44 is repeated four times for each message activation (as specified in the Total field of the message definition) Hence the values of P8 will be 4, 3, 2, and 1 on successive transmissions of the message. The transmissions are then sequentially sent to the devices specified by the values of V354 (devices 60033, 60032, 60031, and 60030)

b. Sinks for FF01 and FF03 (Messages 12 and 50)

Messages 12 and 50 are both transmitted to the FF01 and FF03 MDMs The message transmissions are routed to these devices using V357 as the message sink

V357 = 60009 + P8$2*2

where
P8 = Number of transmissions remaining for the message
60009 = Device number used as a base for identifying the devices to which transmissions are to be sent.

The dollar sign ($) denotes an integer division Messages 12 and 50 are transmitted twice (as specified in the total field of their message definitions) On the first transmission of the messages the value of P8 is 2. The P8$2*2 term evaluates to 2, hence the message is routed to device number 60011 (FF 3) On the second transmission the value of P8 is 1 The P8$2*2 term evaluates to 0 so that the second transmission is routed to device number 60009 (FF 1).

Sinks for FA03, 4 (Message 24)

c The FA03 and FA04 MDMs have Device numbers 60015 and 60016. Message transmissions are routed to these devices using V358 as the message sink

V358 = P8 + 60014

where
P8 = Number of transmissions remaining for the message
60014 = Device number used as the base for identifying the devices to which transmissions are to be sent.

Message 24 is repeated twice for each message activation (as specified in the total field of the message definition) Hence the values of P8 will be 2 and 1 on successive transmissions of the message The transmissions are then sequentially sent to the devices specified by the values of V358 (devices 60016 and 60015).

d Sinks for SSME Status Read from EIUs (Message 34)

The EIUs are treated as memory units in the IMSIM description of these devices This allows parallel transmission of redundant information to the EIUs on multiple buses The EIUs have Memory Unit numbers 70011, 70012, and 70013. Message transmissions are routed to these units by using V359 as the message sink

V359 = P8 + 70010

where
P8 = Number of transmissions remaining for the message
70010 = Unit number used as the base for identifying the units to which transmissions are to be sent.

Message 34 is repeated three times for each message activation (as specified in the Total field of the message definition) Hence the values of P8 will be 3, 2, and 1 on successive message transmissions. The transmissions are then sequentially routed to the units specified by the values of V359 (units 70013, 70012, and 70011).

e Interval for MIA responses

The delay times for the MIA to respond to read requests is given by V360 Currently the value is 0, thus

V360 = 0

This variable is included to provide for refinements in the future.

f. Length for message 7 (Tasks 42, 91, and 180)

The length of message 7 (Read from FF1, FF2, and FF3) is task-dependent and is specified by V361

```
V361 = DFN(X(V107))(
       4   42
       2   91)
```

where
X(V107) = Task number for the task issuing the message

The message length is a discrete function of the task number. The message length will be 4 characters for task 42 and 2 characters for tasks 91 and 180

g Length for Message 23 (Tasks 40, 41, 52, 70, 91, 110, 115, and 120)

The length of message 23 (Read from FA1 and FA2) is task-dependent and is specified by V363

```
V363 = DFN (X(V107))(
        8    40
        4    52
       14    70
        2    91
       14   110
        8   120
```

where
X(V107) = Task number for task issuing the message

The message length is a discrete function of the task number The message length will be 2 characters for task 91, 4 characters for task 52, 8 characters for tasks 40, 41, and 120, and 14 characters for tasks 70, 110, and 115

h Length for Message 25 (Tasks 101, 110, and 114)

The length of message 25 (Read from FA3, and FA4) is task-dependent and is specified by V365 .

```
V365 = DFN(X(V107))(
      26    101
       4    110
       2    114)
```

where
X(V107) = Task number for the task issuing the message

The message length is a discrete function of the task number The message length will be 26 characters for task 101, 4 characters for task 110, and 2 characters for task 114

i. Length for Message 27 (Tasks 101, 102, 110,and 114)

The length of message 27 (Read from FA1 and FA2) is task-dependent and is specified by V370.

```
V370 = DFN (X(V107)))
   30    101
   56    102
  122    110
    2    114)
```

where
X(V107) = Task number for the task issuing the message

The message length is a discrete function of the task number The message length is 2 characters for task 114, 30 characters for task 101, 56 characters for task 102, and 122 characters for task 110.

j Length for Message 26 (Tasks 101, 102, 110, and 114)

The length of message 26 (Read from FA1 and FA2) is task-dependent and is specified by V379

```
V379 = DFN(X(V107)) (
    2    101
    4    110
    2    114)
```

where
X(V107) = Task number for the task issuing the message

The message length is a discrete function of the task number. The message length will be 2 characters for tasks 101, 102, and 114, and 4 characters for task 110

k Sinks for FF Messages (Messages 6, 8, 10, 20, 38, and 52)

The FF MDMs have device numbers 60009 (FF1), 60010 (FF2), 60011 (FF3), and 60012 (FF4) Message transmissions are routed to these devices using V380 as the message sink

```
V380 = P8 + 60008
```

where
P8 = Number of transmissions remaining for the message
60008 = Device number used as the base for identifying the devices to which transmissions are to be sent

The message definitions utilizing V380 are repeated two to four times for each message activation (as specified in the Total field of the message definitions). The number of repetitions is fixed for each message definition. When Total is set to 4, the values of P8 will be 4, 3, 2, and 1 on successive transmissions, and the devices to which each successive transmission is sent will have the device numbers 60012, 60011, 60010, and 60009. When the Total field is set to a 2, the message is transmitted to Devices 60010 and 60009.

l. Sinks for FA Messages (Messages 23, 26, 40, 46, and 53)

The FA MDMs have device numbers 60013 (FA1), 60014 (FA2), 60015 (FA3), and 60016 (FA4). Message transmissions are routed to these devices using V381 as the message sink.

V381 = P8 + 60012

where
P8 = Number of transmissions remaining for the message
60012 = Device number used as the base for identifying the devices to which transmissions are to be sent

The message definitions utilizing V381 are repeated two to four times for each message activation (as specified in the Total field of the message definitions). The number of repetitions is fixed for each message definition. When Total is set to 4, the values of P8 will be 4, 3, 2, and 1 on successive transmissions and the numbers of the devices to which each successive transmission is sent will be 60016, 60015, 60014, and 60013 (in order). When the Total field is set to a 2, the message is sent to Devices 60014 and 60013.

m. Sinks for DDU Messages (Message 54)

Message 54 is used to simulate the writes to the DDUs. Message 54 is repeated twice (as specified in the Total field of the message definition). Each time the message is transmitted, the sink is varied so that the message is routed to a different DDU. V382 is used to define the sink for the message.

V382 = P8 + 60016

where
P8 = Number of transmissions remaining for the message
60016 = Device number used as the base number for identifying the device to which transmissions are to be sent.

On the first transmission the value of P8 is 2, and the message will be routed to device number 60018 (i.e., DDU 2). On the second transmission the P8 value is 1 and the message is routed to device number 60017 (i.e., DDU 1).

n. Sources for ICC Messages (Message 28)

The Intercomputer Communication (ICC) message 28 is transmitted from GPCs 2, 3, and 4 to GPC 1 Message 28 is repeated three times per task activation (as specified in the Total field of the message definition). On each transmission, the source is varied through V383

V383 = P7 + 70001

where
P7 = Number of transmissions remaining for the message
70001 = Memory Unit number used as the base number for identifying from which unit transmissions are to be sent

For the purpose of simulating message traffic between GPCs, the transmissions are made between the GPC memory units The values of P7 on successive message transmissions will be 3, 2, and 1. Hence the sources for the three repetitions of message 28 will be 70004 (GPC 4), 70003 (GPC 3), and then 70002 (GPC 2)

o. Sinks for ICC Messages (Message 29)

The Intercomputer Communication (ICC) message 29 is transmitted from GPC 1 to GPCs 2, 3, and 4 Message 29 is repeated three times per task activation (as specified in the Total field of the message definition) On each transmission, the sink is varied through V384

V384 = P8 + 70001

where
P8 = Number of transmissions remaining for the message
70001 = Memory Unit number for identifying the unit to which the transmissions are to be sent

For the purpose of simulating message traffic between CPCs, the transmissions are made between the GPC memory units. The values of P8 on successive message transmissions will be 3, 2, and 1 Hence the sinks for the three repetitions of message 29 will be 70004 (GPC 4), 70003 (GPC 3), and then 70002 (GPC 2).

p. Length for Message 39 (Tasks 91, 171, and 180)

Message 39 corresponds to a read operation from the four FF MDMs The length of the messages is specified by V387 and is task and transmission dependent.

```
V387 = DFN (X(V107) P7)(
   32    91    1
   20    91    2
   32    91    3
   20    91    4
    6   171    1
   12   171    2
    6   171    4
   14   180    1
    8   180    4)
```

where
X(V107) = Task number for task activating the message
P7 = Number of transmissions remaining to be sent during this activation.

Message 39 is repeated four times (as specified by the Total field of the message definition). Each time the message is transmitted, the source is varied through V380 so that the message will, in turn, be transmitted from FF4, FF3, FF2, and FF1. Each FF MDM transmits a different amount of information. Furthermore, the message length is task-dependent. These dependencies are described in the form of a discrete function in the above variable definition. For task 91, the message length is 32 characters on the first (FF4) and third (FF2) transmissions, and the length is 20 characters on the second (FF3) and fourth (FF1) transmissions. For task 171, the message length is 6 characters on the first and fourth transmissions, and 12 characters on the second and third transmissions. For task 180, the message length is 14 characters for the first three transmissions and 8 characters on the fourth transmission.

q. Length for Messages 84 and 85 (Task 116)

Messages 84 and 85 (Write ET Umbilical commands to FA2 and FA4) are issued once during events 33 (MECO confirmed) and 33A (Enable MPS dump). The length of the messages is specified by V389 which is a function of gate G1601.

```
V389 = DFN (G1601) (0    0   4   1)
```

The length of the messages is four characters when gate G1601 is set to a 1. When the gate is 0, the message lengths are 0, thereby effectively suppressing the messages. The IMSIM simulation sets G1601 to a 1 during events 33 and 33A. After the messages have completed once, the gate is reset to 0 to prevent any further transmissions of messages 84 and 85.

r. Length for Message 41

Message 41 transfers MCA status information from FA1, FA2, FA3, and FA4. The message is repeated four times (as specified in the Total field of the message definition). Each time the message is transmitted, the source is varied through V381 so that the message will, in turn, be transmitted from FA4, FA3, FA2, and then FA1. Each FA MDM transmits a different amount of information; hence the message length is specified by V392 which is an algebraic function of the ordinal message transmission number (and indirectly a function of the message source).

V392 = 26 - P7$3*2 - P7$4*4

where
P7 = Number of message transmissions remaining to be sent during the task activation.

The dollar sign ($) defines an integer division. Thus the length of the message transmission (in characters) may be determined from the following table:

Ordinal Transmission	P7 Value	Source	Length (characters)
1	4	60016 (FA4)	20
2	3	60015 (FA3)	24
3	2	60014 (FA2)	26
4	1	60013 (FA1)	26

s. Sinks for Message 42

Message 42 is used to simulate the initiation of the Main Propulsion System (MPS) status transfer from the FA2 and FA4 MDMs. The message transmissions are routed to these devices using V393 as the message sink.

V393 = 60014 + P8$2*2

where
P8 = Number of transmissions remaining for the task activation
60014 = Device number used as a base for identifying the devices to which transmissions are to be sent.

The dollar sign ($) denotes an integer division. Message 42 is transmitted twice (as specified in the Total field of the message definition). On the first transmission of the message the value of P8 is 2. The P8$2*2 evaluates to 2; hence the message is routed to device number 60016 (FA4). On

the second transmission the P8 value is 1. The P8$2*2 term evaluates to 0 so that the message is routed to device number 60014 (FA2).

t. Length for Message 45

Message 45 transfers SRB status information from the SRB MDMs LL1, LL2, LR1, and LR2. The single message prototype is repeated four times (as specified in the Total field of the message definition). Each time the message is transmitted, the source is varied through V354 so that each repetition will, in turn, be transmitted from LR2, LR1, LL2, and then LL1. Each SRB MDM transmits a different amount of information; hence the message length is specified through V395 which is an algebraic function of the ordinal transmission number (and indirectly a function of the message source).

V395 = 32 + P7$2*10 - P7$3*4

where
P7 = Number of message transmissions remaining to be sent during the task activation.

The dollar sign ($) specifies an integer divide. Thus the length of the message transmission (in characters) may be determined from the following table:

Ordinal Transmission	P7 Value	Source	Length (characters)
1	4	60033 (LR2)	38
2	3	60032 (LR1)	38
3	2	60031 (LL2)	42
4	1	60030 (LL1)	32

u. Length for Message 47 (Tasks 49, 91, 101, 110, 119, 120, 165, 183, and 193)

The length of message 47 (Reply from FA1, 2, 3, and 4) is specified by V396 and is task and transmission dependent

```
V396 = DFN(X(V107)  P7) (
    2    49    1
    4    91    1
   28   110    1
   26   110    3
   22   110    4
    2   119    1
    4   165    1
    2   183    1
   16   193    1)
```

where
X(V107) = Task number for the task issuing the message
P7 = Number of transmissions remaining to be sent during this activation

The message length is a discrete function of the task number and the transmission number Based on the above definition, the transmission number only affects the lengths of the task 110 transmissions of the message. For all other tasks the length will be the same for each of the four repetitions of the message The length of each transmission is two characters for tasks 49, 119, 120, and 183, four characters for tasks 91, 101, and 165, and 16 characters for task 193 Each time task 110 is activated, the first transmission (to FA4) is 22 characters, the second transmission (to FA3) is 26 characters, and the third and fourth transmissions (to FA2 and FA1) are 28 characters

v Length for Message 53 (Tasks 50, 70, and 182, and 183)

The length of message 53 (Write to FA1, FA2, FA3, and FA4) is task dependent and is specified by V397.

```
V397 = DFN(X(V107)) (
   14    50
    8    70
    6   182)
```

where
X(V107) = Task number for the task issuing the message

The message length is a discrete function of task number. The message length will be 14 characters for task 50, 8 characters for task 70, and 6 characters for tasks 182 and 183.

w Length for Messages 64, 65, 66, and 67 (Tasks 60, 62, 64, 70, 91, 114, 161, 165, 190)

The length of this group of messages (Write commands to FA1, FA2, FA3, and FA4) is task and gate dependent The message length is specified with V398.

```
V398 - DFN(X(V107)G1604) (
   14    16    0
   10    62    0
    6    64    0
    0    91    0
    4    91    1
    6   114    0
    4   161    0)
```

where
X(V107) = Task number for the task issuing the message
G1604 = Gate to indicate a faulty or leaking RCS thruster (1 = YES, 0 = NO)

In the above definition, the G1604 setting only affects the message length for task 91. The message length is 14 characters for task 60; 10 characters for task 62; 6 characters for tasks 64, 70, and 114; and 4 characters for tasks 161, 165, and 190. When the messages are activated by task 91, the length is 4 characters if there is a faulty RCS thruster condition, but is 0 (i.e., no messages for this task) otherwise.

x. Sinks for Messages 69, 70, 71, 72

This group of messages will transmit four redundant messages to the Master Event Controllers (MECs). For the purpose of accurately simulating four parallel transmissions to the MECs, the MECs are treated as Memory Units so that the four redundant messages can be sent simultaneously along buses FC5, FC6, FC7, and FC8. Each message is sent to both MECs. V424 is used for this purpose.

V424 = 70013 + P8

where
P8 = Number is transmissions remaining for the message
70013 = Unit number used as the base for identifying the unit to which transmissions are to be sent.

The message definitions using V424 as message sinks are repeated twice for each message activation (as specified in the Total field of the message definition) The value of P8 prior to the first transmission is 2, and therefore the sink is 70015 (MEC 2). After the first transmission, P8 has the value of 1, and the second message transmission is sent to unit 70014 (MEC 1).

y Length for Messages 79, 80, 81 and 82 (Tasks 91, 161, and 190)

The length of this group of messages (Write commands to FF1, FF2, FF3, and FF4) is task and gate dependent. The message length is specified by V426.

```
V426 = DFN(G1604 X(V107)) (
   0     0     91
   4     0    161)
```

where
X(V107) = Task number for the task activating the message
G1604 = Gate to indicate a faulty or leaking RCS thruster (1 = YES, 0 = NO)

In the definition of V426, the G1604 setting only affects the message length for task 91. The message length for tasks 161 and 190 is four characters, irrespective of the G1604 setting. For messages activated by task 91, the length is four characters when there is a faulty thruster indication, but is 0 (i.e., no messages for task 91) otherwise.

z Length for Message 43 (Task 116)

The length of message 43 (Read propulsion status from FA2 and FA4) is controlled through a gate and is specified by V426.

```
V427 = DFN(G1602) (0   0   2   1)
```

The length of message 43 is two characters when G1602 is set to a 1 and is zero length (i.e., no message) when G1602 is 0. The gate G1602 is used to control when message 43 is transmitted during the MPS dump sequence (event 33A), gate G1602 is set to a 1 value 150 ms after message 84 completes during the MPS dump sequence A single two-character message is transmitted Once message 43 completes the gate, (and hence the message length) is reset to 0, thereby effectively suppressing all further transmissions of the message.

aa. Length for Messages 69, 70, 71, and 72 (Tasks 114, 115, 116, and 164)

The length of this group of messages (Write commands to Master Event Controllers [MEC] 1 and 2) is task and gate dependent. The message length is specified by V437.

```
V437 = DFN(G1603 X(V107)) (
   0     0     0
  24     1   114
   6     1   115
   4     1   116
   6     1   164)
```

In the above definition, the message length is nonzero when gate G1603 is set to 1. The length will be zero when G1603 is set to 0; thereby effectively suppressing the message. Thus the gate controls the MEC write commands within the R/S Launch, SRB Separation, ET Separation, or Range Safety sequences. Gate G1603 is set by IMSIM. When the MEC commands are issued (i e , when G1603 = 1), the message length is 24 characters for task 114 (R/S Launch sequence), 6 characters for tasks 115 (SRB Separation Sequencer) and 164 (Range Safety Function); and 4 characters for task 116 (ET Separation Sequencer).

5 2 1 6 Timing, Clocks, and Gates. A number of variables are used in the determination of time-slice segments.

a 80 Ms Time-slice

For some model routines a simple indicator of the presence or absence of the 80 ms time is required This is accomplished via 366.

```
V366 = X660 ' 2
```

By performing remainder division by 2, if a 1 results, this indicates an 80 ms time-slice

b. Set Time for Savex 660 - Variable 371

```
   ''SET TIME FOR SAVEX 660

V371 = V375 + V376

V372 = C1'80

V373 = C1'320

V374 = V1'2000

V375 = DFN (V372, V373)(
    111       0      0
    001       0     40
    011       0    160
    001       0    200
    000      40      0)

V376 = DFN (V374)(
   11000      0
       0     40
    1000   1000
       0   1040)
```

Savex 660 indicates the processing time slice. Values for time-slices of 40, 80, 160, 320, 1000, and 2000 are generated by performing remainder division of clock time (V372, V373, and V374) and by defining logical bit settings (V375 and V376) for the results, followed by combination of these results

```
   ''SET TIME SLICE COUNTER X657

V377 = X657'12 + 1
```

c 40 ms Time-Slice Counter used by V438

The computation time for routine 206 varies over successive 40 ms intervals The computation time variable for this routine utilizes V414 which is defined as follows:

V414 = X656'12

By performing remainder division by 12 on the 40 ms time-slice counter maintained in X656, the computation time function can be made to vary over 12 successive execution cycles for routine 206

d Mission Elapsed Time (MET) Variable

The MET time is computed using V417

V417 = C1 - X662

The IMSIM parameter C1 provides the current simulation clock time in milliseconds,and the Savex cell X662 provides the simulated time at which the MET clock was started

e Half-Cyclic Interval Determination Variable

In some task activations it is necessary to determine the midway point for that task's cyclic interval to synchronize its dispatch. This half-cycle interval is given by V425

V425 = X(V415)$2 + 10

The term X(V415) gives the cyclic interval between activations for a given task This cyclic interval is then divided by 2 to provide the half-cycle interval

f Time-Slice Counter for X688

V428, used to set the Savex cell X688, is defined as follows:

V428 = X656'4

Remainder division by 4 is performed on the 40 ms time-slice counter maintained in X656 Hence, the V428 will evaluate to the values 0, 1, 2, or 3

g. Two clocks will be generated, viz.,

- o Countdown clock
- o MET clock

The countdown clock will initially be set to -20 seconds in tenths of seconds (X661 - 200) The clock will be decreased by 1 second every 100 ms if countdown is not in "Hold"

When the countdown clock goes to zero, the countdown clock stops and the MET clock will be set to the simulation clock time so that the MET time can be properly calculated using V417.

The logic flow diagrams for the countdown and time-slice determination is given in figures 5-9 and 5-10.

The MODLIT code to accomplish the countdown and MET is given in section 5.2 1 7

h Task History Print Control

The task history print is controlled through gate G43 A value of 1 (i e., G43 = 1) results in the printing of the task history and a value of 0 (i.e , G43 = 0) suppresses the print.

i. Message History Print Control

The message history print is controlled through gate G44 A value of 1 (i e , G44 = 1) results in the printing of the message transmission and a value of 0 (i e , G44 = 0) suppresses the print

J Transmission Control for Messages 84 and 85

The transmission of messages 84 and 85 during the ET separation sequence (task 116) is controlled through the gate G1601 When G1601 = 1, the message length specified by V386 is four characters, and when G1601 = 0, the messages are suppressed. The setting of gate G1601 is performed in the NASA-unique IMSIM revisions described in section 5 2 1 7

k Transmission Control for Message 43

The transmission of message 43 during the ET separation sequence (task 116) is controlled by gate G1602. When G1602 = 1, the message 43 length variable, V427, is two characters; when G1602 = 0, message 43 is suppressed. The setting of gate 1602 is performed in the NASA-unique IMSIM revisions described in section 5.2.1 7

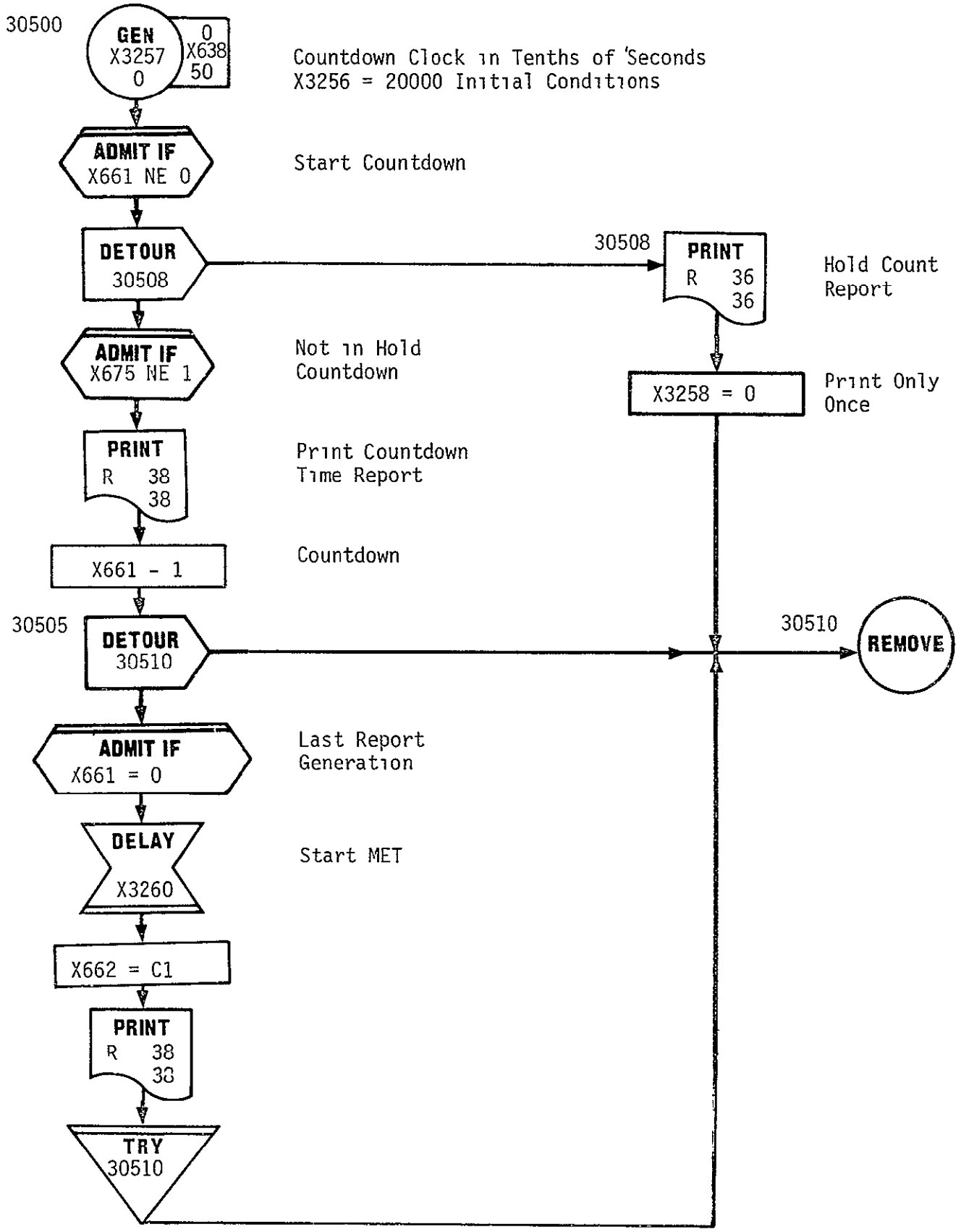
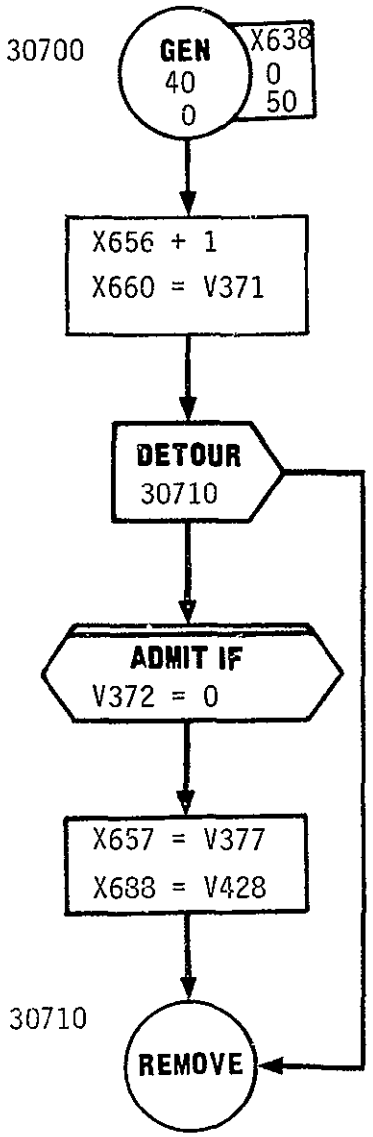


Figure 5-9. Countdown and MET Clock Logic



Determine 40 ms and 80 ms Time-Slice

Set 40 ms Counter Set Time-Slice

Not 80 ms Slice

80 ms Slice

Set 80 ms Counter

Figure 5-10. Time Slice Counter Logic

l Transmission Control for Messages 69 through 72

The transmission of messages 69 through 72 (write commands to MECs 1 and 2) is controlled by gate G1603. The messages are issued as part of the SRB and ET separation sequences (tasks 115 and 116) and the range safety logic (task 164) When G1603 = 1 during any of the sequences, the messages have a nonzero length defined by V437 When G1603 = 0, the messages are suppressed

The logic flow diagrams to accomplish the message transmission control, indicated in sections j, k and l, are given in figure 5-11

m. Routine Initialization Gate

A number of routines require a different computation time for their initial execution. A gate -G(V299)- is used to determine whether or not it is the first execution of the routine The gate has a 0 value on the first execution and will have a value of 1 on all subsequent executions of the routine.

V299 = 5000 + X(V107)

n Faulty Thruster Gate

Gate 1604 is used as the communication gate for routines to indicate a faulty thruster (G1604 = 1)

The logic flow diagram is given in figure 5-12.

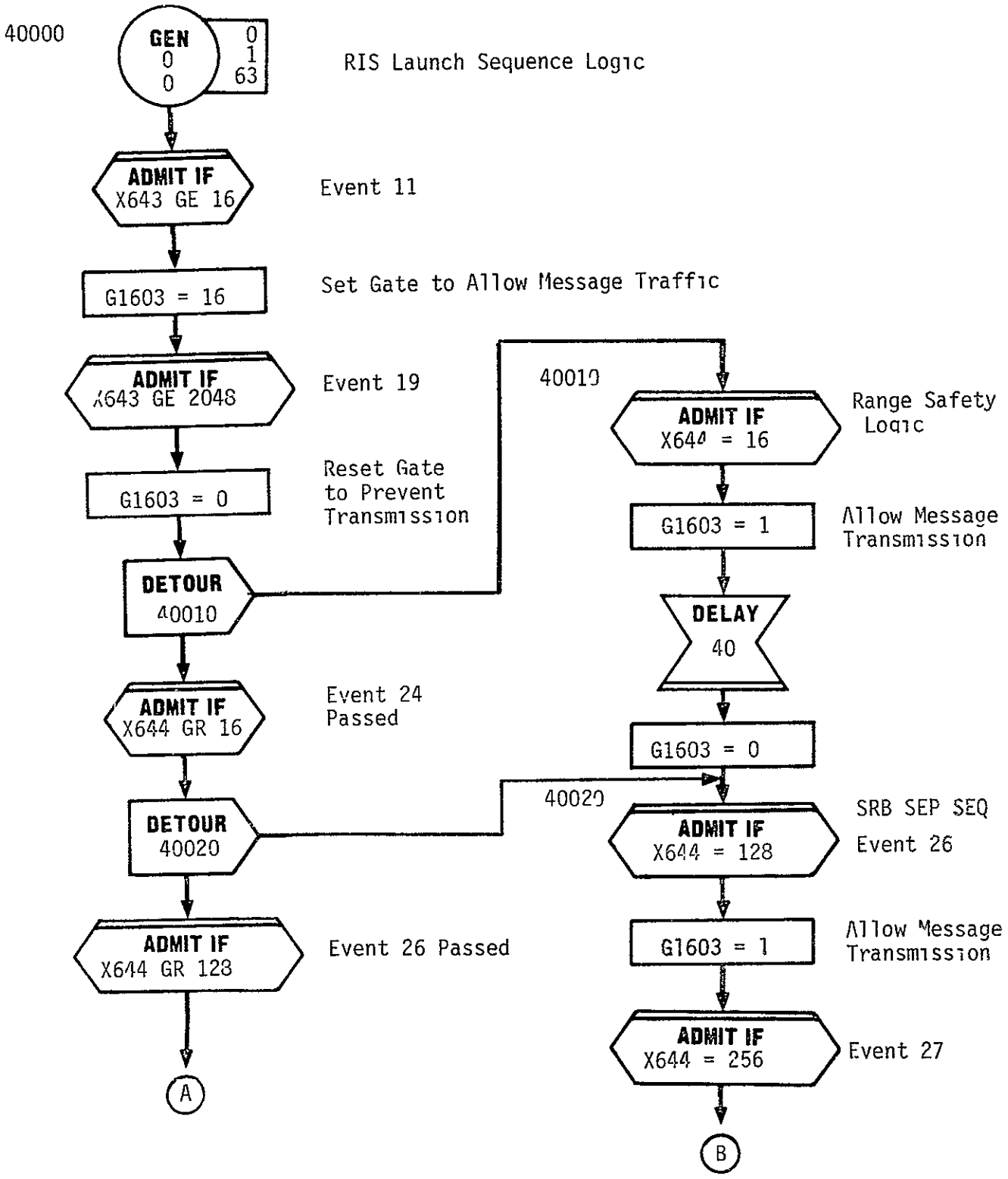


Figure 5-11 Redundant Set Launch Sequence et al Processing Logic

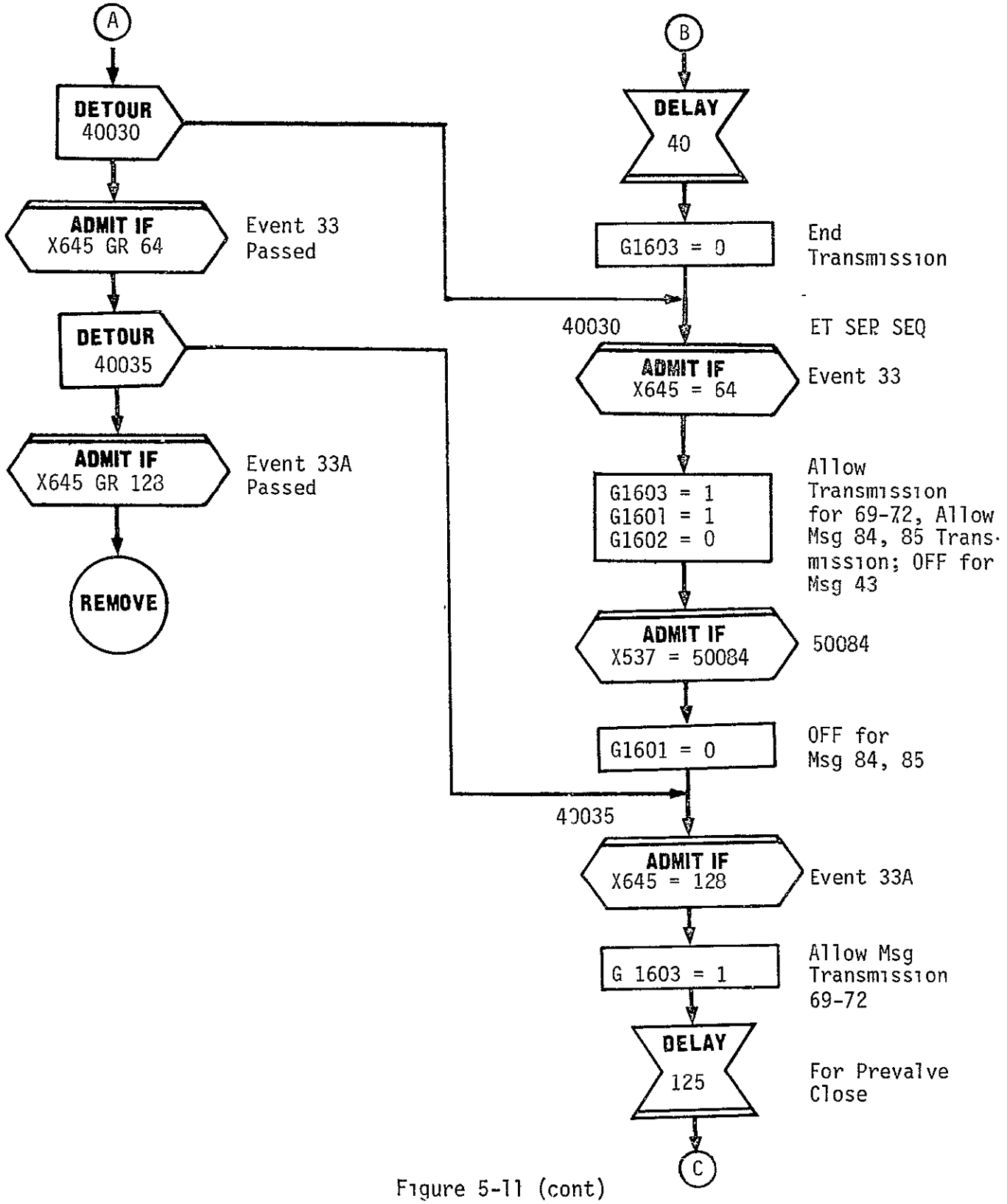


Figure 5-11 (cont)

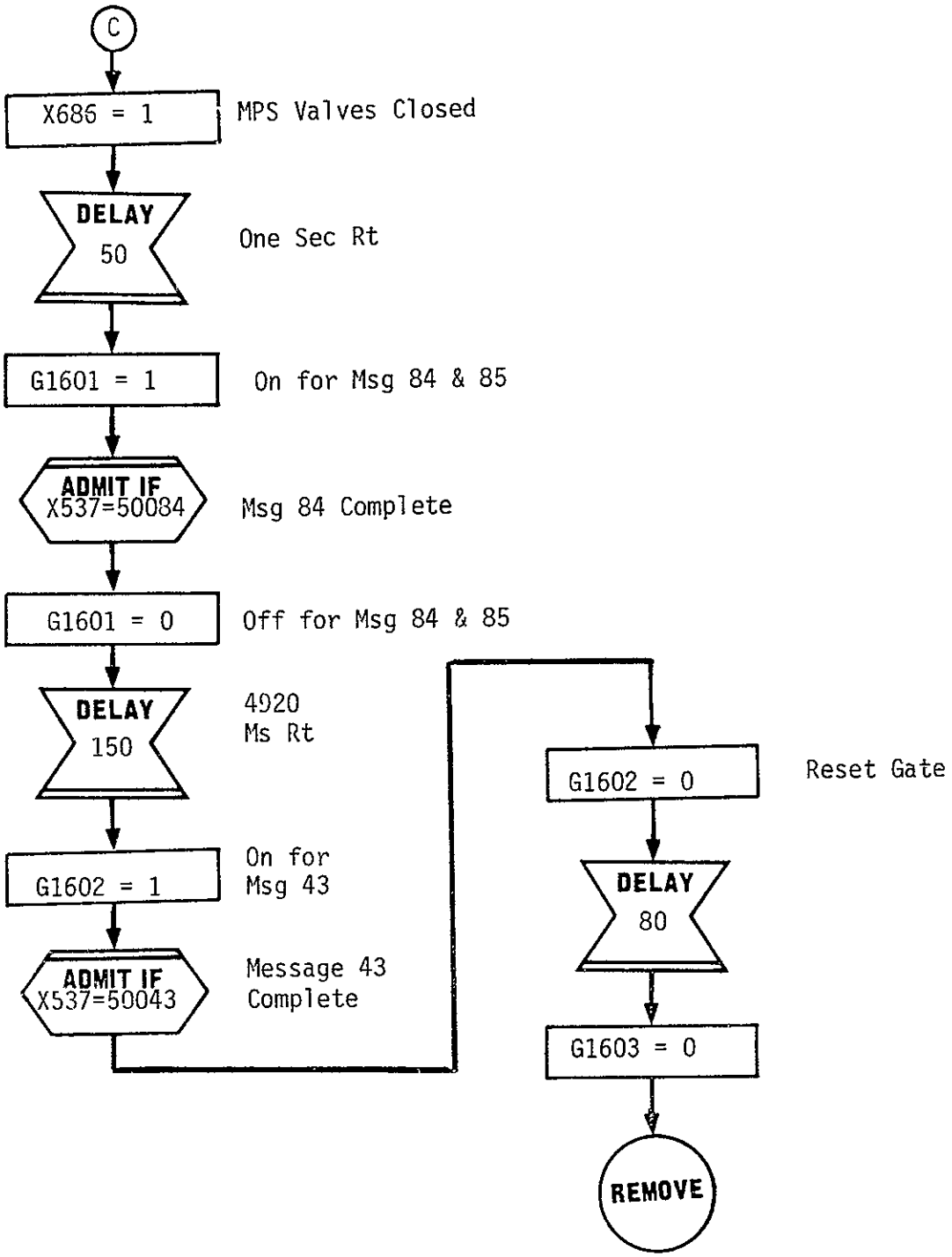


Figure 5-11 (cont)

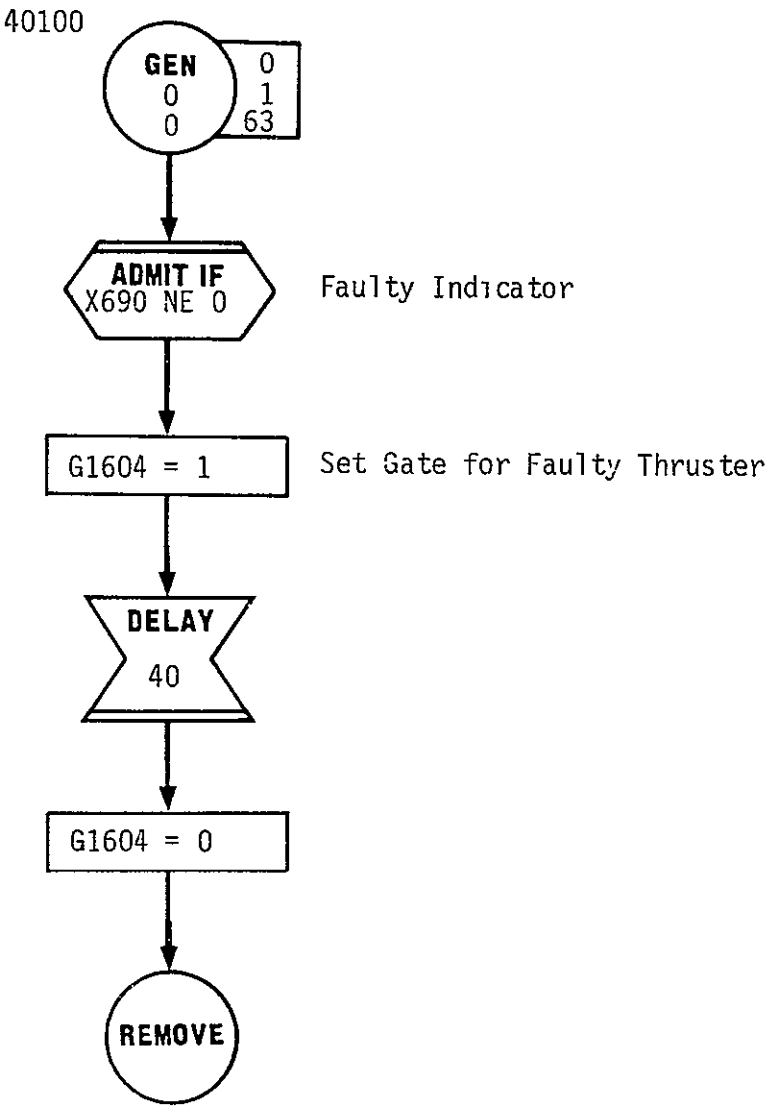


Figure 5-12 Faulty Thruster Monitor

5 2 1 7. NASA-Unique IMSIM Revisions. IMSIM was adapted for NASA-unique conditions with the following changes

a. Cyclic activation of Principal Functions

b User Interface activation

c. Event mask generation

d Countdown clock

e Determine 40 ms and 80 ms time-slice

f Set Cyclic Interval changes

g Redundant Set Launch Sequence Processing, Range Safety logic, SRB Separation logic, ET Separation Sequence logic

h. OMS Fire Sequence generation

i Faulty Thruster monitor

j Event-related report generation

k Delivery of computational units by routines

l. Task activation tally

5.2 1 7 1 Cyclic Activation of Principal Functions. The determination of the start of cyclic execution of Principal Functions, and the termination of same, is accomplished by the following IMSIM revisions.

```
      ''PRINCIPAL FUNCTIONS TASK GENERATION
20000 GEN   0   0   X639   0   50 ''START TRANSACTIONS FOR PRINCIPAL FNCS
      ADMIT IF X3255 LS X3254 ''ADMIT ONLY NUMBER OF ENTRIES IN V409
      X3255 + 1               ''COUNTER STARTING AT 0
      A10 = X3255
      P1 = 416                ''SET VARIABLE NUMBER FOR MULTIPLE STARTS
      P4 = V409               ''DETERMINE TASK NUMBER
20010 P6 = V409               ''FOR A10 MULTIPLE START INDEX
      P8 = V410               ''MAJOR MODE START CONDITION
      P9 = V411               ''EVENT MASKS START CONDITION
      P10 = V412              ''MAJOR MODE TERMINATE CONDITION
      P11 = V413              ''EVENT MASKS TERMINATE CONDITION
      P12 = 1                 ''FIRST PASS INDICATOR
```

```
20013 DETOUR 20018              ''WAIT FOR ACTIVATION CONDITION
      ADMIT IF V364 GE 0        ''START TASK ACTIVATION IMMEDIATELY
20014 DETOUR 20015              ''START OF CYCLIC OPERATIONS
      ADMIT IF V407 GE 0        ''TERMINATE CONDITION
      DETOUR 20020              ''FOR MULTIPLE START FUNCTIONS
      ADMIT IF V(P1) = 0        ''ONCE ONLY START FUNCTIONS
20017 REMOVE                    ''ALL DONE
20015 ADMIT IF X568 = 0         ''ACTIVATION ROUTINE
      X568 = P4                 ''SET TASK ACTIVATION SAVEX
      X577 = P4                 ''SET FUNCTION NUMBER
      PRINT R 31 31             ''GO MSG FOR TASK
      PR1 + 0                   ''PROCESS FUNCTION ACTIVATION
      X568 = 0                  ''RESET SAVEX
      PRINT R 30 30             ''FUNCTION ABORT REPORT
      X659 + V436               ''ABORT COUNTER
      X577 = 0                  ''RESET FUNCTION NUMBER AFTER ABORT
      DETOUR 20019              ''NORMAL CYCLIC INTERVAL
      ADMIT IF P12 = 1          ''SYNCHRONIZE 1ST PASS
      P12 = 2                   ''PREVENT NEXT PASS
      DETOUR 20019              ''TO NORMAL INTERVAL
      ADMIT IF V420 GR V425     ''SYNC ONLY IF TIME OVER HALF
      DELAY V420                ''SYNCHRONIZE FUNCTION
      TRY 20014                 ''NEXT TIME CYCLIC OPERATION
20019 DELAY X(V415)             ''CYCLIC INTERVAL FOR ACTIVATION
      TRY 20014                 ''NEXT CYCLIC OPERATION
20018 SAVE X(P8)                ''STATE VECTOR/MAJOR MODE
      ADMIT IF X(P9) NE P6
      POP                       ''RESTORE STACK
      TRY 20013
20020 A10 = V416
      A10 + X3254
      TRY 20010                 ''MULTIPLE START FUNCTIONS
20030 GEN   0   0   X638   13   50 ''CONTINUOUS TASKS
      X3251 + 1                 ''START AT X3253
      A10 = X3251               ''FOR INDEX INTO V421
      P4 = V421
20035 ADMIT IF X568 = 0
      X568 = P4                 ''SET TASK ACTIVATION SAVEX
      X577 = P4                 ''SET FUNCTION NUMBER
      PR1 + 0                   ''PROCESS FUNCTION ACTIVATION
      PRINT R 31 31             ''GO MSG FOR TASKS
      X568 = 0                  ''RESET SAVEX
      PRINT R 30 30             ''FUNCTION ABORT REPORT
      X659 + V436               ''ABORT COUNTER
```

```
      X577 = 0
      DELAY X(V415)            ''CYCLIC INTERVAL FOR ACTIVATION
      TRY 20035                ''FOR CONTINUOUS CYCLIC OPERATION
20040 GEN   0   0   X638   0   50 ''INITIAL TASKS THAT TERMINATE
      ADMIT IF X3252 LS X3253
      X3252 + 1                ''START AT 0
      P1 = 10                  ''NO REPEATING TASKS (V10=0)
      A10 = X3252              ''FOR INDEXING INTO TERMINATE CONDITS
      P4 = V421                ''DETERMINE TASK NUMBER
      P10 = V422               ''MAJOR MODE TERMINATE CONDITION
      P11 = V423               ''EVENTS MASKS TERMINATE CONDITION
      P12 = 2                  ''PREVENT SYNCHRONIZATION DELAY
      TRY 20015                ''TASK ACTIVATION
```

5.2.1.7 2 User Interface Activation. The determination of User Interface actions and the subsequent disposition of these actions is accomplished by the following IMSIM revisions

```
20400 GEN  X3276  0   X641   0   50 ''GENERATE FOR USER INTERFACE
      ADMIT IF X669 GE 1       ''KEYBOARD ACTION
      ADMIT IF X568 = 0
      X568 = 334               ''SET FUNCTION ACTIVATE SAVEX
      X577 = 334               ''SET FUNCTION NUMBER
      PR1 + 0                  ''PROCESS ACTIVATION USER INTERF.
      PRINT R 31 31            ''GO MSG FOR TASKS
      X568 = 0                 ''RESET SAVEX
      PRINT R 30 30            ''FUNCTION ABORT
      X659 + V436              ''ABORT COUNTER
      X577 = 0
20402 DELAY 1
      COPY TO V388             ''PROCESS KEYBOARD ACTIONS
      X669 = 0                 ''CLEAR KEYBOARD
      X670 = 0                 ''HOUSEKEEP SPEC FUNCTION
      X671 = 0                 ''HOUSEKEEP ITEM INPUTS
      TRY 20410
20405 DETOUR 20410
      ADMIT IF X663 NE X666    ''GN&C MODE CHANGE
      X666 = X663              ''MAINTAIN CURRENT GN&C MODE
20410 REMOVE
20420 DETOUR 20410
      ADMIT IF X670 NE 0
      DELAY 1                  ''FOR CODE SPEC FUNCTIONS
      TRY 20410
20430 DETOUR 20410
      ADMIT IF X671 NE 0
      X674 = 2                 ''FOR DISPLAY FUNCTIONS
      TRY 20410
20440 DETOUR 20410
      ADMIT IF X671 NE 0
      DELAY 1                  ''FOR CODE ITEM ENTRIES
      TRY 20410
```

5.2.1.7.3 Event Mask Generation The generation of the event occurrences and the setting of the event masks for all major modes except the countdown mode are accomplished by the following IMSIM revisions.

```
      ''GENERATE EVENT MASKS FOR EACH MAJOR MODE
      ''SET X643 = 1 IN INITIAL CONDITIONS
30000 GEN  X3278  0  X698  0  50
      ADMIT IF C1 GE X3277       ''IN MM101 THRU JOBSCHEDULE
30010 DETOUR 30015
      ADMIT IF X644 = 0          ''FIRST TIME AROUND
      X644 = 1                   ''SET FIRST EVENT
      X663 = 102                 ''SET MAJOR MODE 102
30003 X3280 = 1                  ''EVENT COUNTER FOR RPT 40
30004 PRINT R 40 40              ''PRINT EVENT OCCURRENCE RPT
30005 REMOVE
30015 DETOUR 30020               ''IF NOT MM 102
      ADMIT IF X644 LE 256
      X644 + X644                ''SET NEXT EVENT
30019 X3280 + 1                  ''INCREASE EVENT COUNTER
      TRY 30004
30020 DETOUR 30025
      ADMIT IF X645 = 0          ''FIRST TIME AROUND
      X645 = 1                   ''SET FIRST EVENT
      X663 = 103                 ''SET MAJOR MODE 103
      TRY 30003
30025 DETOUR 30030               ''IF NOT MM103
      ADMIT IF X645 LE 512
      X645 + X645                ''SET NEXT EVENT
      TRY 30019
30030 DETOUR 30035
      ADMIT IF X646 = 0          ''FIRST TIME AROUND
      X646 = 1                   ''SET FIRST EVENT
      X663 = 104                 ''SET MAJOR MODE 104
      TRY 30003
30035 DETOUR 30040
      ADMIT IF X646 LE 128
      X646 + X646                ''SET NEXT EVENT
      TRY 30019
30040 DETOUR 30045
      ADMIT IF X647 = 0          ''FIRST TIME AROUND
      X647 = 1                   ''SET FIRST EVENT
      X663 = 105                 ''SET MAJOR MODE 105
      TRY 30003
30045 DETOUR 30050               ''IF NOT MM 105
      ADMIT IF X647 LE 128
      X647 + X647                ''SET NEXT EVENT
      TRY 30019
30050 X663 = 106                 ''SET MAJOR MODE 106
      TRY 30019
```

5.2.1.7.4 Countdown Clock A countdown clock logic was generated for a countdown in tenths of seconds, checking for a "Hold Countdown", and starting the MET clock was accomplished by the following IMSIM revisions.

```
      ''COUNTDOWN CLOCK IN TENTHS OF SECONDS
      ''S X3256 = 20000  INITIAL CONDITIONS
30500 GEN   X3257   0   0   X638   50
      ADMIT IF X661 NE 0          ''START COUNTDOWN
      DETOUR TO 30508
      ADMIT IF X675 NE 1          ''NOT IN HOLD COUNTDOWN
      PRINT R 38 38               ''PRINT COUNTDOWN TIME REPORT
      X661 - 1                    ''COUNTDOWN
30505 DETOUR 30510
      ADMIT IF X661 = 0           ''LAST COUNTDOWN GENERATION
      DELAY X3260
      X662 = C1                   ''START MET
      PRINT R 38 38               ''LAST COUNTDOWN REPORT
      TRY 30510
30508 PRINT R 36 36               ''PRINT HOLD COUNT REPORT
      X3258 = 0                   ''PRINT ONLY ONCE
30510 REMOVE
```

5 2 1 7 5 Determine 40 ms and 80 ms Time-Slice. Determination of 40 ms or 80 ms time-slice with a 40 ms and 80 ms counter was accomplished by the following IMSIM revisions

```
      ''DETERMINE 40 MS & 80 MS TIME SLICE
30700 GEN  40   0   X638   0   50
      X656 + 1                    ''SET 40 MS COUNTER
      X660 = V371                 ''SET TIME SLICE
      DETOUR 30710                ''IF NOT 80 MS
      ADMIT IF V372 = 0           ''80 MS SLICE
      X657 = V377                 ''SET 80 MS COUNTER
      X688 = V428
30710 REMOVE
```

5 2.1.7 6 Set Cyclic Interval Changes. Three Principal Functions, viz 1, 19, and 206, change their execution rates during the various major modes in OPS 1. The following revisions to IMSIM accomplish this rate change at the appropriate times

```
      ''SET CYCLIC INTERVAL CHANGES FOR TASKS 6, 19 & 206
30800 GEN   0   0   X638   1   50
      P1 = 30801                ''RETURN BLOCK FOR RT 30820
      P8 = 644                  ''MAJOR MODE 102
      P9 = 1                    ''EVENT 19
30801 DETOUR 30820
      ADMIT IF V364 GE 0        ''CHANGE CYCLIC INTERVAL
      X3274 = 160               ''INTERVAL NOW 160 MS FOR TASK 19
      P1 = 30802                ''RETURN BLOCK FOR RT 30820
      P9 = 2                    ''EVENT 21
30802 DETOUR 30820
      ADMIT IF V364 GE 0        ''CHANGE CYCLIC INTERVAL
      X3273 = 500               ''INTERVAL NOW 500 MS FOR
      X3274 = 500               ''TASKS 6 & 19
      P1 = 30803                ''RETURN BLOCK FOR RT 30820
      P8 = 645                  ''MAJOR MODE 103
      P9 = 1                    ''EVENT 28
30803 DETOUR 30820
      ADMIT IF V364 GE 0        ''CHANGE CYCLIC INTERVAL
      X3274 = 2000              ''INTERVAL NOW 2000 MS FOR TASK 19
      P1 = 30804                ''RETURN BLOCK FOR RT 30820
      P9 = 16                   ''EVENT 31
30804 DETOUR 30820
      ADMIT IF V364 GE 0        ''CHANGE CYCLIC INTERVAL
      X3274 = 500               ''INTERVAL NOW 500 MS FOR
      X3275 = 500               ''TASKS 19 & 206
      P1 = 30805                ''RETURN BLOCK FOR RT 30820
      P9 = 32                   ''EVENT 32
30805 DETOUR 30820
      ADMIT IF V364 GE 0        ''CHANGE CYCLIC INTERVAL
      X3274 = 2000              ''INTERVAL NOW 2000 MS FOR TASK 19
      REMOVE                    ''ALL DONE
30820 SAVE X(P8)                ''STATE VECTOR/MAJOR MODE
      ADMIT IF X(P9) NE P6      ''STATE VECTOR CHANGED
      POP                       ''RESTORE STACK
      TRY P1                    ''FOR CYCLIC CHANGE CHECK
```

5.2 1 7 7 Redundant Set Launch Sequencing. The R/S Lnch Seq logic, Range Safety logic, SRB Separation sequencer logic, and ET Separation sequence logic are all contained in the following revisions to IMSIM·

```
      ''REDUNDANT SET LAUNCH SEQUENCE PROCESSING LOGIC (TASK 114)
40000 GEN   0   0   0   1   63
      ADMIT IF X643 GE 16        ''EVENT 11
      G1603 = 1                  ''SET GATE TO ALLOW MESSAGE TRAFFIC
      ADMIT IF X643 GE 2048      ''EVENT 19
      G1603 = 0                  ''RESET GATE TO PREVENT TRANSMISSION
      DETOUR 40010               ''RANGE SAFETY LOGIC
      ADMIT IF X644 GR 16        ''EVENT PASSED
      DETOUR 40020               ''SRB SEPARATION LOGIC
      ADMIT IF X644 GR 128       ''EVENT PASSED
      DETOUR 40030               ''ET SEPERATION LOGIC
      ADMIT IF X645 GR 64        ''EVENT PASSED
      DETOUR 40035               ''CONTINUED ET SEP LOGIC
      ADMIT IF X645 GR 128       ''EVENT PASSED
      REMOVE
      ''RANGE SAFETY LOGIC (TASK 164)
40010 ADMIT IF X644 = 16         ''EVENT 24
      G1603 = 1                  ''ALLOW MESSAGE TRANSMISSION
      DELAY 40
      G1603 = 0                  ''RESET GATE TO TERMINATE XMIT
      ''SRB SEPARATION SEQUENCER LOGIC (TASK 115)
40020 ADMIT IF X644 = 128        ''EVENT 26
      G1603 = 1                  ''ALLOW TRANSMISSION MESSAGES
      ADMIT IF X644 = 256        ''EVENT 27
      DELAY 40
      G1603 = 0                  ''TERMINATE TRANSMISSION
      ''ET SEPARATION SEQUENCE LOGIC (TASK 116)
40030 ADMIT IF X645 = 64         ''EVENT 33
      G1603 = 1                  ''ALLOW MSG TRANSMISSION FOR 69 - 72
      G1601 = 1                  ''ALLOW MSG 84, 85 TRANSMISSION
      G1602 = 0                  ''OFF FOR MSG 43
      ADMIT IF X537 = 50084      ''MESSAGE 84 COMPLETED
      G1601 = 0                  ''OFF FOR MSG 84 & 85
40035 ADMIT IF X645 = 128        ''EVENT 33A
      G 1603 = 1                 ''ALLOW MESG TRANSMISSION FOR 69 - 72
      DELAY 125                  ''FOR PREVALVE CLOSE
      X686 = 1                   ''MPS VALVES CLOSED
      DELAY 50                   ''ONE SEC RT
      G1601 = 1                  ''ON FOR MESSAGES 84 & 85
      ADMIT IF X537 = 50084      ''MESSAGE 84 COMPLETE
      G1601 = 0                  ''OFF FOR MSG 84 & 85
      DELAY 150                  ''4920 MS RT
      G1602 = 1                  ''ON FOR MESSAGE 43
      ADMIT IF X537 = 50043      ''MESSAGE 43 COMPLETED
      G1602 = 0                  ''RESET GATE
      DELAY 80
      G1603 = 0
      REMOVE
```

5 2.1 7 8 OMS Fire Sequence Generation. The logic for the OMS Fire Sequencing is contained in the following revision to IMSIM:

```
      ''OMS FIRE SEQUENCE GEN
40050 GEN   0   0   X639   2   51
40051 ADMIT IF V403 GE 1        ''DETERMINE FIRE SEQ
      X683 = V403               ''SET SAVEX SEQ.
      DELAY 40
      DETOUR 40051
      ADMIT IF V403 = 0
      REMOVE
```

5.2.1 7 9 Faulty Thruster Monitor The logic for a faulty thruster indication is contained in the following revision to IMSIM:

```
      ''FAULTY THRUSTER MONITOR
40100 GEN   0   0   0   1   63
      ADMIT IF X690 NE 0        ''FAULTY INDICATOR
      G1604 = 1                 ''SET GATE FOR FAULTY THRUSTER
      DELAY 40
      G1604 = 0
      REMOVE
```

5.2 1.7 10 Event related Report Generation The logic for generating reports 35 (transition to next major mode) and 37 (OMS engine failure) is contained in the following revision to IMSIM.

```
      ''EVENT RELATED REPORT GENERATION
40200 GEN   0   0   0   0   50
      ADMIT IF X663 NE X666
      PRINT R 35 35
      X666 = X663
      REMOVE
40220 GEN   0   0   0   0   50
      ADMIT IF X685 NE 0
      PRINT R 37 37
      X3259 = 0
      REMOVE
```

5.2 1.7 11 Computation Units Delivery By Routines The following revision to IMSIM accomplished the delivery of computation time units by a routine when executed instead of by message.

```
REVISE 905000 905000              ''PREVENT COMP TIME FROM MESSAGES
      ADMIT IF X(P2) = 1
```

5 2 1 7 12 Task Activation Tally The following revision to IMSIM generates a table tally on the number of cyclic function activations

```
REVISE 220000
      TALLY 1 1                   ''COUNT TASK ACTIVATIONS FOR SUMMARY

TABLE 1 = P5 706 1 800            ''TASK ACTIVATION SCORES
```

5 2 1 8 GO/NOGO Settings. V401, V402 and V408 are used to establish GO/NOGO conditions for tasks. V401 will be set to GO (=1) when the appropriate system state conditions exist for its execution This system state condition is tested in the logic for the Principal Function activation as described in section 5 2 1 3 Listed below are the GO/NOGO variables used in the model

```
      ''GO/NOGO SETTING FOR JOBS 2, 3, 4, & 5
V401 = DFN (V402) (0 -1  1  0  0  1)
V402 = X568 - X(V107)
      ''GO/NOGO FOR TASK 183
V408 = DFN (X685 V403)(
     0     0     0
     1     0     2)            ''INCLUDES ALL "1" SETTINGS FOR X685
```

5 2 1.9 Miscellaneous Variable Functions.

a. V339 - Mass Memory Access Time. This was not simulated during this OFT study, but is referenced here for continuity purposes Mass Memory access time is specified as having a range of 500 ms to 8000 ms This condition is simulated by V399

```
V399 = X44 + V400
V400 = CFN (RF1) (Matrix Values)
X44 is a Savex constant of 500 ms
V400 is a randomly generated value having a range of 0 to-7500 ms.
```

b V383 and V384 - Memory Determination for ICC messages. V384 is used for the memory determination (sink) of the ICC messages generated by each of the four GPCs

```
V384 = P8 + 70001
```

V383 is used to determine the source memroy for the ICC messages generated by each of the four GPCs

```
V383 = P7 + 70001
```

c V364 and V407 - Starting Terminating Event Occurrence Determination V364 and V407 are used in the logic for determination of a change in system state by comparing the stored event occurrence mask with the present system state.

```
      ''STARTING EVENT OCCURRENCE DETERMINATION
V364 = X (P8) - P9
      ''TERMINATING EVENT DETERMINATION
V407 = X(P10) - P11
```

d. V367 - Platform Release. This variable tests the value of Savex Cell X673 to determine, through remainder division by 2, if the last bit of the value is a 1 or 0. When the last bit is a 1, it indicates that the IMU platform is released.

```
V367 = X673'2
```

e V385 - New Display Determination. Variable 385 is a discrete function of Savex cell X669. At a setting of 3 or 15, computations for a new display will have to be done.

```
V385 = DFN (X669) (Matrix Values)
```

f V388 - Branch Conditions for Keyboard Input. This variable defines the block locations to where the program must branch dependent or what keyboard action (X699) was taken.

```
        ''BRANCH CONDITIONS FOR KEYBOARD ACTIONS
V388 = DFN (X669)(
     20410     0      ''NULL
     20405     1      ''OPS CHANGE
     20420     2      ''SPEC FUNCTION
     20430     3      ''DISPLAY
     20440     4      ''ITEM DEF.
     20410     6)     ''OTHER ACTIONS
```

g V403 - OMS Fire Sequence Operations. The OMS Fire sequencing is a discrete function of the system state as set in Savex cell X646 (for MM104) or as set in Savex cell X647 (for MM105)

```
        ''MATRIX FOR OMS FIRE SEQ OPS
V403 = DFN (X646    X647)(
    0       0         0
    1       1         0
    2       2         0
    3       4         0
    0     128         0
    1     256         4
    2     256         8
    3     256        16
    0     256       128)
```

h V404 and V406 - Countdown. These variables are used in the countdown logic. V404 determines the reduction factor, and V406 the interval during countdown.

(Page 5-130 blank)

```
      ''REDUCTION FACTOR COUNTDOWN
V404 - X3256$X3277
      ''INTERVAL FOR COUNTDOWN
V406 = X3277$V355
```

d V444 - Assigned Core Memory. This variable was set to 70001 for memory #1 for this simulation.

```
V444 = 70001
```

5.2.1.10 Parameterization. The model has been parameterized with the parameters listed in appendix B under NASA SPECS50.DATA and adapted with the values and revisions listed in appendix A under NASA.REVAR54.DATA.

For the simulation runs without data messages, the model was parameterized with parameters for file NASA.T5NM0 DATA, which were identical to the SPECS50 parameters with the exception of the deletion of all data messages (IMSIM' input form 5) and all references thereto.

5.2.2 Sensitivity Analysis

Following the Data System Requirements Definition Task, and prior to establishing a specific simulation configuration and its operational modes, a sensitivity analysis of the proposed Space Shuttle Orbiter Data Processing Subsystem was conducted. The primary sources of information and data used to conduct the sensitivity analysis were references 8, 15, and 18. From a detailed review of the referenced documents five potential data processing bottleneck problem areas were defined. The potential problem areas were identified as:

a. CPU Utilization

b. FC and SSIP Processing

c. The GPC/PCMMU interface

d. CPU synchronization

e. Multifunction Display processing

The process by which the five potential problem areas were identified was based on a detailed review of the technical tasks to be performed by the DDPS, the characteristics of the hardware and software to be used in performing these technical tasks, and the operational environment (flight phases, operational modes, etc.) within which the tasks would be required.

The final configuration and operational mode of the IMSIM/modeled Orbiter Digital Data Processing Subsystem provided data for only one of the five potential problem areas identified (CPU utilization). However, each potential problem area is discussed in this section to indicate why it was initially identified.

5 2 2.1 CPU Utilization. From a detailed review of the Orbiter DDPS tasks to be performed for various operational modes, and the requirement that the CPU be capable of handeling cyclic tasks plus noncyclic special tasks (such as Selection Filtering), the question of the CPU's capability to perform all required tasks within an allocated time period was identified as a potential problem area. The question was raised by the somewhat high computation times derived for high priority tasks This problem area was selected as the principal problem area to be investigated.

Based upon this decision the IMSIM model described in this report was adapted to investigate the potential CPU utilization problem.

5 2.2.2 FC and SSIP Processing. Critical applications represent the highest level of processing for OFT missions. Within the critical applications, the processing is broken into Flight Control (FC) and System Software Interface

Processing (SSIP). Both FC and SSIP processing is performed at a 40 ms rate, and the processing is of nearly equal priority. The initiation of SSIP and FC operations is phased so there is no overlap when operating under nominal conditions. Furthermore, the execution timing of the FC plus the SSIP processing must not exceed 40 ms. Any time not used by the FC and SSIP processing within the 40 ms time slot is used for lower-level applications.

The FC processing during the ascent phase largely consists of transport delays in a feedback loop. The allowable transport lag (measured from the time rate gyro and accelerometer assembly inputs leave the MDM to the time the high rate effector writes, based on these inputs, arrive at the MDM) is less than 15 ms (See section 4.4.2 of reference 18). Normally the initiation of FC processing is somewhat time critical, so it is important that the processing be initiated in a timely manner. Accordingly there is a requirement on the FC executive that the variation in process initiation and input times shall be no more than ±2% of the iteration interval for 96% of the iterations in a 1-second interval and never greater than 4 ms (See section 4.4.2 of reference 18). The relatively small, unvarying amount of I/O and the fixed duration of the FC processing eliminates FC itself as a potential problem area. Process initiation represents the only potential problem area. However, initiation of FC processing would only be affected by other processing of equal or higher priority. Specifically, a problem would exist if the duration of SSIP operations was long enough to delay FC process initiation. Normally, this will not occur but can potentially create problems under off-nominal conditions. Thus, SSIP operations under off-nominal conditions appear to be a potential problem area for critical operations. Furthermore, FC operations are somewhat invariant and are unlikely to result in a processing bottleneck except for backup flight control system processing.

5 2.2 3 The GPC/PCMMU Interface The PCMMU is an intermediate data transfer unit between the GPCs and seven operational instrument data subsystems and between the GPCs and the payload data subsystem Within the total Shuttle Orbiter DDPS, the CPU and the PCMMU are the only devices that can enable multiplexer interface adapter units for the transmission or reception of serial bus data

Functionally the PCMMU performs the following:

a. Through internal control, it requests input data from the operational instrumentation and payload data subsystems. These data are stored in appropriate PCMMU random access memories.

b. The PCMMU stores data commanded to it from each GPC into toggle buffers and allows any GPC to access all operational instrumentation and payload data.

c. The PCMMU outputs formatted (downlisted) data to a network signal processor which is used to control downlink data.

Operational functions conducted between GPCs and a PCMMU are performed asynchronously within a data cycle which is synchronized between the two units. Because there will be different operational functional requirements between the GPCs and the PCMMU for different operational modes, a potential data processing problem could exist for excessive GPC/PCMMU asynchronous operation and/or for malfunctions of the GPC/PCMMU Data cycle synchronization.

The GPC downlist processing was identified as a potential data processing problem Specifically, a problem would exist if there was a requirement to downlist large amounts of data. The normal GPC downlist supports a data cycle continuity for simultaneous PCMMU downlink transmission rates of 64 KBPS and 128 KBPS However, one GPC is limited to downlisting 128 16-bit words every 40 ms This corresponds to a rate of 51 2KBPS Within a redundant GPC set there is only one GPC operational downlist format Downlist formats reside in main memory except for SM OPS 9 and special dump formats which may be initiated at any time via user input

In the OFT ascent phase, four GPCs will operate in a redundant mode and GPC No. 5 will act as a backup. This means that there will be only one downlist format for the Ascent phase. Moreover, it appears all the downlist parameters identified in reference 19 for the Ascent phase can be represented with 128 16-bit words The downlist parameters represent outputs of the Principal Functions and would be calculated irrespective of the fact that they are being downlisted. Thus, no additional loading is required to generate the downlist parameters.

5.2.2.4 CPU Synchronization. The five GPCs in the Space Shuttle Orbiter are interconnected by serial data buses and can be operated as independent or redundant units. A basic operational design philosophy of the Shuttle Orbiter DDPS is to provide a capability whereby the computations of any one CPU may be verified by other CPUs whenever these CPUs constitute a redundant set. The objective of this capability is to ensure fail-operational and fail-safe system performance during critical flight phases.

To achieve this operational capability, CPU synchronization of all GPCs which constitute a redundant set has been assumed. A potential data processing problem area could be created if CPU synchronization for redundant operations is not maintained.

From the functional design specifications of the DDPS it would appear that adequate hardware and software design considerations have been given to the CPU synchronization requirement. Each GPC contains three real-time clock timers, and systems management synchronizing software programs have been functionally defined.

While the possibility of nonsynchronization of CPUs for redundant set operation may have been minimized by the system design, the consequences of its occurence warrant its consideration as a potential problem area to be studied by simulation. For this reason, it was so identified in the sensitivity analysis.

Because the IMSIM Model configured to study CPU Utilization was constructed on the ground rule that only one active GPC need be simulated (because all other GPCs would have identical loading), the problem of CPU synchronization was not addressed. A specific model should be developed to assess this potential problem area. The present model is not appropriate, as it employs a 1-millisecond time unit.

5.2.2.5 Multifunction Display Processing. The multifunction CRT display system has been designed to provide the principal flight crew interface for data entry, subsystem monitoring, program selection, and the presenting of alphanumeric and graphic data displays. A variety of fixed display formats and types of displays are defined by the software system to be used. Operationally, most display format skeletons are stored on mass memory. However, all critical display formats are stored in the DEU and, if not there, in the GPC memory. Because DEU transactions can be extremely long in duration, it is preferable to minimize the retrieval of display formats from mass memory or the GPC. There is a maximum of two display formats defined for the OFT ascent phase. This will minimize the amount of display processing required. Furthermore, the update rate for displayed parameters is at most once every 0.5 second. This is unlikely to result in any significant data processing loading problems.

5.2 3 Test Design (SOW 3.3)

Based on the results of Task 1 - Requirements Definition and Model Adaptation, and Task 2 - Sensitivity Analysis, a test design was developed, incorporating the findings of these previous tasks The Test Design resulted in.

a the model generation, described in detail in section 5.2 3.1.

b the model's adaptation and parameterization, described in detail in section 5 2 1, and

c the job schedule inputs, described in detail in section 5.2.4.

5 2 3 1 Model Generation This section describes the inputs and required formats for building and parameterizing the IMSIM model. Nine "input specification form" categories (forms 6 through 14), as described in section 5.1.3, are used for defining the hardware configuration. These inputs are described and listed in section 5 2 3 2 below.

Five input specification form categories (forms 1 through 5) are employed in specifying software workload characteristics. These inputs are described and listed in section 5 2 3.3.

The inputs on these 14 specification forms were assembled for execution in the NASA.SPECS50 DATA, and the NASA T5NMO DATA files.

A printout of these files is contained in appendix B

5 2.3.2 Hardware Simulation The simulated hardware is described in detail by

a. Processors
b Memories
c. Mass Memory Storages
d. Devices
e. Datalinks

The parameters for the hardware simulation were derived as follows

a For hardware that was identical to that used in the Approach and Landing Test study, from the Final Report on the DDPS Dynamic Loading Analysis, TM-(5658/000/00 (reference 4). These parameters were extracted from the following documents·

1) Computer Program Development Specification. No. SS-P-002-110A, Volume 1, Book 1 (Revised), Level A Hardware,

2) Computer Program Development Specification, No. SS-P-0002-130A, Volume 1, Book 3, Launch Data Bus Software Interface Requirements.

3) Computer Program Development Specification, No. SS-P-0002-410A-2, ALT Functional Level Requirements, Volume IV, Book 1 (Revised), Guidance, Navigation, and Control

4) Functional Subsystem Software Requirements System Interface, Volume 6, Parts 1 and 2, Sections 1 through 11, and Appendices A through K. Orbiter 101.

5) Space Shuttle Advanced System/4Pi - Model AP-101, Central Processor Unit, Technical Description

b. For hardware that was new to the OFT Configuration, parameters were extracted from the following references.

1) For the Master Events Controller (MEC) from Rockwell International Space Division, SD-74-SH-0230 B, Data Processing Subsystem Description and Performance Document (Reference 15) and Lockheed Electronics Company, Aerospace Systems Division, LEC-5870 Subsystem Description - Shuttle Electrical Power Distribution and Control, Section 3 4 - Events Control (Reference 21).

2) For the Engine Interface Unit (EIU) from Rockwell International Space Division, coordination draft for SD-76-SH-0026, Space Shuttle OFT, Level C, Functional Subsystem Software Requirements Document (FSSR), Guidance Navigation and Control (Reference 12) and Rockwell International Space Division, SD-74-SH-0230 B, Data Processing Subsystem Description and Performance Document (Reference 15)

5.2 3 2 1 Processors Four processors were simulated, one for each of the four GPC complexes

Each of the GPC processors for the IBM 4pi/AP101 computer has a command execution time of 1 4 microseconds (processing speed of 714300 instructions per second) and is designated as belonging to Virtual Machine #1. The 4pi/AP101 central processor can respond to the following interrupts

- I/O
- Bounds Fault
- Service request

There is no task switch time involved.

The approach was to simulate the four GPCs as all belonging to one Virtual Machine. One processor was represented as actively servicing all tasks while the other three processors were operating passively in the redundant mode, assuming to process identical tasks, but with actual ICC messages interchanging between GPC memories for synchronization The specifications are contained in a data set NASA.SPECS50.DATA. Format description is given in section 5.1 3 and in the IMSIM User's Manual (reference 2)

The scripted inputs for the processors on IMSIM specificaton form 9 were as follows.

```
''CENTRAL PROCESSING UNIT (CPU) NO. 1
''      SPEED  CLASS  INTERRUPT  SWITCH  VIRT MACH  CONNECTED MEMORIES
9    1  0.48    10        5         0       1        1
''
''CENTRAL PROCESSING UNIT (CPU) NO. 2
''      SPEED  CLASS  INTERRUPT  SWITCH  VIRT MACH  CONNECTED MEMORIES
''   2  0.48    10        5         0       2        2
''
''CENTRAL PROCESSING UNIT (CPU) NO. 3
''      SPEED  CLASS  INTERRUPT  SWITCH  VIRT MACH  CONNECTED MEMORIES
''   3  0.48    10        5         0       3        3
''
''CENTRAL PROCESSING UNIT (CPU) NO. 4
''      SPEED  CLASS  INTERRUPT  SWITCH  VIRT MACH  CONNECTED MEMORIES
''   4  0.48    10        5         0       4        4
```

5 2.3 2 2 Memories

a. Four core memories--70001 through 70004--were simulated, one for each GPC The main memory for each IBM/4pi AP-101 computer has a total capacity of 436K bytes. The main memory access rate was simulated at 750 μs (speedfactor of 1 4 bytes/microsec.). The page size in these memories was simulated at 2048 bytes with a total of 212 pages for each memory.

   During the OFT Ascent Phase Simulation, Memory Configuration #1 was in core permanently and no other Memory Configurations were required.

   As memory configurations will all be predetermined prior to flight, no problems were expected as to memory capacity, therefore no division was simulated for the Major Function GN&C overlay or the Ops overlays. The size of the routines are therefore also immaterial, and a nominal value of 1 was used on the specification forms

The scripted inputs for these core memories on form 7 were as follows.

```
''MEMORY GPC 1
''          SPEED FACTOR          PAGES
7    1          1.4                212
''
''MEMORY GPC 2
''          SPEED FACTOR          PAGES
7    2          1.4                212
''
''MEMORY GPC 3
''          SPEED FACTOR          PAGES
7    3          1.4                212
''
''MEMORY GPC 4
''          SPEED FACTOR          PAGES
7    4          1.4                212
```

b Three Engine Interface Units (EIUs)--70011 through 70013--were simulated as memories to permit redundant concurrent transmissions. The access rate for these memories was simulated at 16 67 μs (speedfactor of 0.06 bytes/μs), being consistent with the 1 MHz data bus rate The page size in these memories was simulated at 2048 bytes with a memory capacity of one page for each of these memories

The scripted inputs for these units on IMSIM specification form 7 were as follows

```
''ENGINE INTERFACE UNIT (EIU) 1
''          SPEED FACTOR          PAGES
 7  11          0.06                 1
''
''ENGINE INTERFACE UNIT (EIU) 2
''          SPEED FACTOR          PAGES
 7  12          0.06                 1
''
''ENGINE INTERFACE UNIT (EIU) 3
''          SPEED FACTOR          PAGES
 7  13          0.06                 1
''
```

c. Two Master Event Controllers (MECs)--70014 through 70015--were simulated as memories to permit redundant concurrent transmissions The access rate for these memories was simulated at 16.67 μs (speedfactor of 0.06 bytes/ microsec), being consistent with the 1 MHz data bus rate

The scripted inputs for these controllers on IMSIM specification form 7 were as follows·

```
''MASTER EVENTS CONTROLLER (MEC) 1
''          SPEED FACTOR          PAGES
 7  14          0.06                 1
''
''MASTER EVENTS CONTROLLER (MEC) 2
''          SPEED FACTOR          PAGES
 7  15          0.06                 1
''
```

5 2 3 2 3 Mass Memory Storages Two Mass Memory Storages were simulated These Mass Memories were not used in this simulation study, but are included for continuity Both are identical in their characteristics and are simulated as two tape units, each tape with a 17,000,000 byte capacity (134 X 10^6 bits) Access time to the unit was simulated as V400 and V399 with a minimum of 0.5 seconds and a maximum of 8 seconds for each tape unit (See section 5.2.1.9 for details on these random variables.) Transmission rate for each unit was set for 125 bytes/ms

The scripted inputs for the mass memory storages on form 8 were as follows

```
''MASS MEMORY STORAGE (MM) NO. 1
''          A/D  SHARE  CYCLE  TRX RATE  CAPACITY   ACCESS PERIOD
8    1       1      1      0       125    17000000   399  500  0  0  0
''
''MASS MEMORY STORAGE (MM) NO. 2
''          A/D   SHARE  CYCLE  TRX RATE  CAPACITY   ACCESS PERIOD
8    2       1      1      0       125    17000000   399  500  0  0  0
```

5 2.3.2 4 Devices The following devices were simulated

a. Sixteen Multiplexer/Demultiplexers (MDMs)--60009 through 60016 and 60030 through 60037--which can be shared among tasks. Maximum record size each can hold was simulated at 1024 bytes.

Input and output rates were simulated at 60 bytes/ms. No reset time required.

The scripted inputs for these units on IMSIM specification form 6 were as follows

```
''MULTIPLEXER/DEMULTIPLEXER (MDM) FF1
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   9     1      1         1024            60           60      0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) FF2
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   10    1      1         1024            60           60      0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM)  FF3
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   11    1      1         1024            60           60      0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM)  FF4
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   12    1      1         1024            60           60      0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM)  FA1
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   13    1      1         1024            60           60      0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM)  FA2
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   14    1      1         1024            60           60      0
''MULTIPLEXER/DEMULTIPLEXER (MDM)  FA3
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   15    1      1         1024            60           60      0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM)  FA4
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   16    1      1         1024            60           60      0
''MULTIPLEXER/DEMULTIPLEXER (MDM) LL1
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   30    1      1         1024            60           60      0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) LL2
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   31    1      1         1024            60           60      0
```

```
''MULTIPLEXER/DEMULTIPLEXER (MDM) LR1
''      A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''           CLASS      SIZE          INPUT      OUTPUT   PERIOD
6   32    1     1        1024            60          60     0
''MULTIPLEXER/DEMULTIPLEXER (MDM) LR2
''      A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''           CLASS      SIZE          INPUT      OUTPUT   PERIOD
6   33    1     1        1024            60          60     0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) LF1
''      A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''           CLASS      SIZE          INPUT      OUTPUT   PERIOD
6   34    1     1        1024            60          60     0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) LA1
''      A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''           CLASS      SIZE          INPUT      OUTPUT   PERIOD
6   35    1     1        1024            60          60     0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) PF1
''      A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''           CLASS      SIZE          INPUT      OUTPUT   PERIOD
6   36    1     1        1024            60          60     0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) PF2
''      A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''           CLASS      SIZE          INPUT      OUTPUT   PERIOD
6   37    1     1        1024            60          60     0
```

b Three Display Electronic Units (DEUs)--60001 through 60003--which can be shared among tasks. Maximum record size each can hold was simulated at 8192 bytes.

Input rate was simulated at 60 bytes/ms and output rate at 31 bytes/ms. No reset time required

The scripted inputs for these units on IMSIM specification form 6 were as follows

```
''DISPLAY ELECTRONIC UNIT NO. 1
''      A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''           CLASS      SIZE          INPUT      OUTPUT   PERIOD
6   1     1     1        8192            60          31     0
''
''DISPLAY ELECTRONIC UNIT NO. 2
''      A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''           CLASS      SIZE          INPUT      OUTPUT   PERIOD
6   2     1     1        8192            60          31     0
''
```

```
''DISPLAY ELECTRONIC UNIT NO. 3
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   3    1     1          8192            60          31       0
```

c Three Display Units (DUs)--60005 through 60007--which can be shared among tasks. Maximum record size each can hold was simulated at 8192 bytes Input rate was simulated at 38 bytes/ms No reset time required

The scripted inputs for these units on IMSIM specification form 6 were as follows

```
''DISPLAY UNIT NO. 1
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   5    1     1          8192            38            0      0
''
''DISPLAY UNIT NO. 2
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   6    1     1          8192            38            0      0
''
''DISPLAY UNIT NO. 3
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   7    1     1          8192            38            0      0
```

d Three Display Driver Units (DDUs)--60017 through 60019--which can be shared among tasks Maximum record size each can hold was simulated as unlimited and the Input and Output rates were simulated at 60 bytes/ms No reset time required

The scripted inputs for these units on IMSIM specification Form 6 were as follows:

```
''DISPLAY DRIVER UNIT (DDU) NO. 1
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   17   1     1             0            60          60       0
''
''DISPLAY DRIVER UNIT (DDU) NO. 2
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   18   1     1             0            60          60       0
''
''DISPLAY DRIVER UNIT (DDU) NO. 3
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS       SIZE          INPUT       OUTPUT   PERIOD
6   19   1     1             0            60          60       0
```

e. Two keyboard units (KBUs)--60027 and 60028--which can be shared among tasks No specific record size was simulated The output rate was simulated at 1 byte/ms with a 1 ms delay between.

The scripted inputs for these units on IMSIM specification form 6 were as follows

```
''KEYBOARD UNIT (KBU) NO. 1
''      A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''           CLASS      SIZE          INPUT      OUTPUT   PERIOD
6   27   1     1           0              0           1     1
''
''KEYBOARD UNIT (KBU) NO. 2
''      A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''           CLASS      SIZE          INPUT      OUTPUT   PERIOD
6   28   1     1           0              0           1     1
```

f. Two Pulse Code Modulation Master Units (PCMMUs)--60095 and 60096--which can be used by all tasks. The maximum record size for each unit was simulated at 2048 bytes and the input and output rates were simulated at 60 bytes/ms. No delay required between.

The scripted inputs for these units on IMSIM Specification form 6 were as follows

```
''PULSE CODE MODULATION MASTER UNIT (PCMMU) NO. 1
''      A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''           CLASS      SIZE          INPUT      OUTPUT   PERIOD
6   95   1     1          2048            60          60     0
''
''PULSE CODE MODULATION MASTER UNIT (PCMMU) NO. 2
''      A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''           CLASS      SIZE          INPUT      OUTPUT   PERIOD
6   96   1     1          2048            60          60     0
```

5 2.3 2 5 Datalinks. The following data links were simulated in the OFT configuration as depicted in figure 5-2

a. Five databuses for intercomputer communication--IC1 through IC5 (100001 through 100005)--with a maximum transmission rate of 1 MHz. Each transmitted word is 28 bits, of which 16 bits (= 2 characters or bytes) are data The in-between word time is 5 5μs. Therefore the transmission rate is·

$$\frac{2}{33\ 5} = 59.7 \text{ bytes/ms}$$

For simulation, this has been rounded to 60 characters/ms. The scripted inputs for these datalinks on IMSIM specification form 10 were as follows·

```
''INTERCOMPUTER COMMUNICATIONS DATALINK - IC1
''          MODE   TRANSMISSION RATE     TIME LAG
10    1       0         60                  0
''
''INTERCOMPUTER COMMUNICATIONS DATALINK - IC2
''          MODE   TRANSMISSION RATE     TIME LAG
10    2       0         60                  0
''INTERCOMPUTER COMMUNICATIONS DATALINK - IC3
''          MODE   TRANSMISSION RATE     TIME LAG
10    3       0         60                  0
''
''INTERCOMPUTER COMMUNICATIONS DATALINK - IC4
''          MODE   TRANSMISSION RATE     TIME LAG
10    4       0         60                  0
''
''INTERCOMPUTER COMMUNICATIONS DATALINK - IC5
''          MODE   TRANSMISSION RATE     TIME LAG
10    5       0         60                  0
```

b. Three databuses for Display System communication--DK1 through DK3 (100006 through 100008)--with a maximum transmission rate of 1 MHz. The scripted inputs for these data links on IMSIM specification form 10 were as follows

```
''DISPLAY SYSTEM DATALINK - DK1
''          MODE   TRANSMISSION RATE     TIME LAG
10    6       0         60                  0
''
''DISPLAY SYSTEM DATALINK - DK2
''          MODE   TRANSMISSION RATE     TIME LAG
10    7       0         60                  0
''
''DISPLAY SYSTEM DATALINK - DK3
''          MODE   TRANSMISSION RATE     TIME LAG
10    8       0         60                  0
```

c Eight data buses for Flight Critical communication--FC1 through FC8 (100010 through 100017)--with a maximum transmission rate of 1MHz. The scripted inputs for these data links on IMSIM specification form 10 were as follows:

```
''FLIGHT CRITICAL BUS DATALINK - FC1
''          MODE   TRANSMISSION RATE     TIME LAG
10   10       0         60                  0
''
''FLIGHT CRITICAL BUS DATALINK - FC2
''          MODE   TRANSMISSION RATE     TIME LAG
10   11       0         60                  0
''
''FLIGHT CRITICAL BUS DATALINK - FC3
```

```
''          MODE   TRANSMISSION RATE     TIME LAG
10   12       0          60                 0
''
''FLIGHT CRITICAL BUS DATALINK - FC4
''          MODE   TRANSMISSION RATE     TIME LAG
10   13       0          60                 0
''
''FLIGHT CRITICAL BUS DATALINK - FC5
''          MODE   TRANSMISSION RATE     TIME LAG
10   14       0          60                 0
''
''FLIGHT CRITICAL BUS DATALINK - FC6
''          MODE   TRANSMISSION RATE     TIME LAG
10   15       0          60                 0
''FLIGHT CRITICAL BUS DATALINK - FC7
''          MODE   TRANSMISSION RATE     TIME LAG
10   16       0          60                 0
''
''FLIGHT CRITICAL BUS DATALINK - FC8
''          MODE   TRANSMISSION RATE     TIME LAG
10   17       0          60                 0
```

d Two data buses for Mission Critical communication--PL1 through PL2 (100020 through 100021)--with a maximum transmission rate of 1 MHz. The scripted inputs for these data links on IMSIM specification form 10 were as follows

```
''MISSION CRITICAL DATALINK - PL1
''          MODE   TRANSMISSION RATE     TIME LAG
10   20       0          60                 0
''
''MISSION CRITICAL DATALINK - PL2
''          MODE   TRANSMISSION RATE     TIME LAG
10   21       0          60                 0
```

e Two data buses for Mass Memory communication--MM1 through MM2 (100018 through 100019)--with a maximum transmission rate of 1 MHz. The scripted inputs for these data links on IMSIM specification form 10 were as follows·

```
''MASS MEMORY DATALINK - MM1
''          MODE   TRANSMISSION RATE     TIME LAG
10   18       0          60                 500
''
''MASS MEMORY DATALINK - MM2
''          MODE   TRANSMISSION RATE     TIME LAG
10   19       0          60                 500
```

f Two data buses for Ground Interface communication--LB1 through LB2 (100022 through 100023)--with a maximum transmission rate of 1 MHz. The scripted inputs for these data links on IMSIM specification form 10 were as follows.

```
''GROUND INTERFACE DATALINK - LB1
''          MODE   TRANSMISSION RATE     TIME LAG
10   22       0          60                 0
''
''GROUND INTERFACE DATALINK - LB2
''          MODE   TRANSMISSION RATE     TIME LAG
10   23       0          60                 0
```

g. Four data buses for PCMMU communication--IP1 through IP4 (100024 through 100027)--with a maximum transmission rate of 1 MHz. The scripted inputs for these data links on IMSIM specification form 10 were as follows

```
''PCMMU DATALINK - IP1
''          MODE   TRANSMISSION RATE     TIME LAG
10   24       0          60                 0
''
''PCMMU DATALINK - IP2
''          MODE   TRANSMISSION RATE     TIME LAG
10   25       0          60                 0
''
''PCMMU DATALINK - IP3
''          MODE   TRANSMISSION RATE     TIME LAG
10   26       0          60                 0
''
''PCMMU DATALINK - IP4
''          MODE   TRANSMISSION RATE     TIME LAG
10   27       0          60                 0
```

h Three datalinks for communication between Display Electronic Units and Display Units (100029 through 100031) with a maximum transmission rate of 800 bps The scripted inputs for these datalinks on IMSIM specification form 10 were as follows:

```
''DU1/DEU1 DATALINK
''          MODE   TRANSMISSION RATE     TIME LAG
10   29       0          1                  0
''
''DU2/DEU2 DATALINK
''          MODE   TRANSMISSION RATE     TIME LAG
10   30       0          1                  0
''
''DU3/DEU3 DATALINK
''          MODE   TRANSMISSION RATE     TIME LAG
10   31       0          1                  0
```

1 Four datalinks for communication between Display Electronic Units and Keyboard Units (100033 through 100036) with a maximum transmission rate of 800 bps. The scripted inputs for these datalinks on IMSIM specification form 10 were as follows

```
''KB1/DEU1 DATALINK
''          MODE   TRANSMISSION RATE     TIME LAG
10   33       0           1                 0
''
''KB1/DEU3 DATALINK
''          MODE   TRANSMISSION RATE     TIME LAG
10   34       0           1                 0
''
''KB2/DEU2 DATALINK
''          MODE   TRANSMISSION RATE     TIME LAG
10   35       0           1                 0
''
''KB2/DEU3 DATALINK
''          MODE   TRANSMISSION RATE     TIME LAG
10   36       0           1                 0
```

5.2 3 2 6 Configuration Linkages The System Configuration is simulated through datalink connections. The scripted inputs for these interconnections on IMSIM specification form 12 were as follows

```
''**** SYSTEM CONFIGURATION ******************************************
''
''      THE FOLLOWING FORMS DEFINE THE INTERCONNECTIONS OF DPS COMPONENTS
''      THROUGH DATA LINKS.
''
''       UNIT      DATALINK CONNECTIONS
12      60001       6  29  33
12      60002       7  30  35
12      60003       8  31  34  36
12      60005      29
12      60006      30
12      60007      31
12      60009      10  14
12      60010      11  15
12      60011      12  16
12      60012      13  17
12      60013      14  10
12      60014      15  11
12      60015      16  12
12      60016      17  13
12      60017      10  11  12  13
12      60018      10  11  12  13
12      60019      10  11  12  13
12      60027      33  34
```

```
12      60028     35  36
12      60030     22  23
12      60031     22  23
12      60032     22  23
12      60033     22  23
12      60034     22  23
12      60035     22  23
12      60036     20  21
12      60037     20  21
12      60095     24  25  26  27
12      60096     24  25  26  27
12      70001      1   2   3   4   5   6   7   8      10  11  12  13   *
                  14  15  16  17  18  19  20  21  22  23  24
12      70002      1   2  25
12      70003      1   3  26
12      70004      1   4  27
12      70011     14  15  16  17
12      70012     14  15  16  17
12      70013     14  15  16  17
12      70014     14  15  16  17
12      70015     14  15  16  17
12      80001     18
12      80002     19
```

5.2 3 2 7 Virtual Machines All CPUs, Memories, IOPs, and devices will be simulated as being contained in one Virtual Machine The capability is reserved to simulate each GPC and its environment as a separate Virtual Machine. The scripted inputs for these Virtual Machines on IMSIM specification form 14 were as follows·

```
''**** VIRTUAL MACHINES ***********************************************
''
''      ONLY ONE VIRTUAL MACHINE IS NEEDED TO REPRESENT THE LDPC FOR THE
''      PURPOSE OF THE CURRENT LOADING STUDY.  HOWEVER, THREE ADDITIONAL
''      VM'S ARE INCLUDED TO DEMONSTRATE A REDUNDANT SET OF FOUR GPC'S.
''
''           EXECUTIVE MEM     VM SIZE        VM PAGE SIZE
14      1         1          1744000             2048
''      2         2          1744000             2048
''      3         3          1744000             2048
''      4         4          1744000             2048
```

5.2.3 3 Workload Specifications The activity which is to be performed in the DDPS model should reflect every significant activity of the DDPS itself. IMSIM workload specification forms enable the model designer to maintain a close correlation between elements of the model workload and the actual DDPS workload. The DDPS processor, modules, and data transmissions were defined as tasks, routines, and messages for the model Static characteristics for each of these system constituents were generally coded directly in the specification forms, however, the dynamic characteristics (those which change as a function of time or system state) were coded as "variables" as described in section 5.2.1, and only cross-references to the appropriate variables are included in the specification forms

All coding for the specification forms is numeric, although comments are associated with each form to describe it for the reader. The following general conventions should be noted

a. The form number appears as the first field of the form (1 = job step, 2 = task, 3 = routine, 5 = message, 11 = data set)

b. An * at the end of a form line indicates that the form is continued on the next line.

c The second field of a form identifies the member of the class defined by the form.

For convenience in defining the workload, four-character designators were assigned to each of the principal functions employed during the OFT ascent phase. These are listed in alphabetic order with reference to assigned IMSIM task numbers in the following table (Note that the task numbers, with the exceptions of 6, 7, and 8, correspond to the section numbers of Principal Functions used in NASA documentation)

Table 5-8. Principal Functions/Tasks

	PRINCIPAL FUNCTIONS	TASK NUMBER
AASP	- ACCELEROMETER ASSEMBLY SOP	42
ADAP	- AERO-JET DIGITAL AUTOPILOT	36
ADIP	- ASCENT DISPLAY PROCESSING	206
AEAP	- AEROSURFACE ACTUATOR CMD SOP	50
AMDP	- ASCENT MANEUVER DISPLAY PROC	210
ARCP	- ASCENT REACTION CONTROL SYSTEM CMD SOP	190
ASAI	- ASCENT ATTITUDE DIRECTOR INDICATOR PROC	168
ASDP	- ASCENT DIGITAL AUTOPILOT	176
ASNS	- ASCENT NAVIGATION SEQUENCER	139
ASNV	- ASCENT NAVIGATION	15
ATTP	- ATTITUDE PROCESSING	97
AUPP	- ASCENT USER PARAMETER PROC	19
AUPS	- ASCENT USER PARAMETER PROC SEQUENCER	197
BFFD	- BODY FLAP CMD FAULT DETECTION, IDENTIFICATION	95
BFFP	- BODYFLAP POSITION FEEDBACK SOP	49
CDIP	- CYCLIC DISPLAY PROCESSOR	335

Table 5-8 (cont)

'' EDFP	- ELEVON DELTA PRESSURE FEEDBACK SOP	193
'' ETSS	- EXTERNAL TANK SEPARATION SEQUENCER	116
'' GAXI	- GUIDANCE, NAVIGATION & CONTROL ANNUNCIATION INTERFACE	110
'' GCSI	- GUIDANCE/CONTROL STEERING INTERFACE	175
'' GEFC	- FAST CYCLE EXECUTIVE	306
'' GMIN	- MINOR CYCLE EXECUTIVE	309
'' GPSW	- GPC SWITCH MONITOR	337
'' GSWP	- GUIDANCE, NAVIGATION & CONTROL SWITCH PROC	180
'' HYSP	- HYDRAULIC SYSTEM SOP	52
'' IDAP	- INSERTION DIGITAL AUTOPILOT	201
'' IMMC	- IMU MAJOR CYCLE EXECUTIVE	319
'' IMRM	- INERTIAL MEASUREMENT UNIT REDUNDANCY MANAGEMENT	72
'' IMUP	- IMU INERTIAL PROCESSING	38
'' LDBP	- LDB I/O PROCESSOR	333
'' MCDS	- MCDS INPUT PROCESSOR	332
'' MOPS	- SPACE SHUTTLE MAIN ENGINE OPERATIONS	165
'' MPSD	- MAIN PROPULSION SYSTEM DUMP SEQUENCER	70
'' MTVP	- MAIN PROPULSION SYSTEM THRUST VECTOR CONTROL CMD SOP	60
'' OASC	- ORBITER ACTUATOR SLEW CHECK	187
'' OING	- ORBIT INSERTION GUIDANCE	8
'' OMFS	- ORBITER MANEUVERING SYSTEM FIRING SEQUENCER	182
'' OMIC	- OMS-TO-OMS INTERCONNECT FUNCTION	183
'' OMQM	- ORBITER MANEUVERING SYSTEM QUANTITY MONITOR	101
'' OMSF	- OMS FAULT DETECTION AND IDENTIFICATION	92
'' ORGP	- ORBITER RATE GYRO SUBSYSTEM OPERATING PROGRAM	40
'' OTFP	- OMS THRUST VECTOR CONTROL FEEDBACK SOP	65
'' OTVP	- OMS THRUST VECTOR CONTROL COMMAND SOP	64
'' RASP	- RADAR ALTIMETER SOP	45
'' RCQM	- REACTION CONTROL SYSTEM QUANTITY MONITOR	102
'' RCSF	- RCS FAULT DETECTION AND IDENTIFICATION	91
'' RHCP	- THREE-AXIS ROTATIONAL HAND CONTROLLER SOP	171
'' RNGS	- RANGE SAFETY FUNCTION	164
'' RSLS	- REDUNDANT SET LAUNCH SEQUENCE PROCESSING	114
'' SFIL	- SELECTION FILTERING	71
'' SMEM	- SPACE SHUTTLE MAIN ENGINE MONITOR FUNCTION	119
'' SMEP	- SPACE SHUTTLE MAIN ENGINE SOP	181
'' SRBM	- SOLID ROCKET BOOSTER MONITOR FUNCTION	120
'' SRDA	- SOLID ROCKET BOOSTER DATA ACQUISITION	203
'' SRGP	- SOLID ROCKET BOOSTER RATE GYRO SOP	41
'' SRSC	- SOLID ROCKET BOOSTER ACTUATOR SLEW CHECK	188
'' SRSS	- SOLID ROCKET BOOSTER SEPARATION SEQUENCER	115
'' SSIP	- SYSTEM SOFTWARE INTERFACE PROCESSOR	307
'' ST1G	- ASCENT FIRST STAGE GUIDANCE	6
'' ST2G	- ASCENT SECOND STAGE GUIDANCE	7
'' STVP	- SRB THRUST VECTOR CONTROL COMMAND SOP	62
'' THCP	- TRANSLATION HAND CONTROLLER SOP	54
'' USIF	- USER INTERFACE	334
'' VNTS	- VENT DOOR CONTROL SEQUENCER	161

5.2.3.3.1 Job Definition The Principal Functions of the OFT Ascent phase were organized into four IMSIM "jobs"

Job 2 - GN&C General Processing

Job 3 - GN&C SOPs, monitoring, and checking

Job 4 - GN&C Sequencing, interfaces, and FDI processes

Job 5 - System Control and User Interface

Job 1 is reserved for the simulation executive. The division of GN&C functions is somewhat arbitrary, but was necessitated by the IMSIM limitation of 24 steps (tasks) per job Since IMSIM permits the same type of task to be invoked for more than one job, task characteristics are divided into two classes: those which pertain to the type of task, and those which relate to the occasion in which the task appears as a step of a job. The latter are included in IMISM form 1 which is discussed in this section.

The four DDPS jobs include 59 independent job steps, corresponding to the 59 types of tasks defined in section 5.2 3 3 2. Each step is assigned a priority, which is subordinate to the task "service class". All of the steps are defined to be cyclic, even though some do not represent inherently cyclic processes, this is done to permit rescheduling of such steps according to events and is essentially an IMSIM technicality

A Go/Nogo condition is specified for each step, to indicate the conditions under which it is to commence or terminate an execution cycle. The condition is coded as the number of a "variable" which is defined in section 5 2.1.8; in general, each condition is a test of an indicator which is manipulated via logic described in section 5 2.1.7 The step is held inactive while the condition variable is zero, and becomes active when the variable assumes a positive, nonzero value.

The scripted input for the jobs on IMSIM Specification form 1 was as follows:

```
''**** JOBS ************************************************************
''
''      FIVE JOBS ARE INCLUDED IN THE MODEL. JOB 1 IS RESERVED FOR THE
''      SIMULATION EXECUTIVE.  JOBS 2 THROUGH 5 ENCOMPASS ALL FUNCTIONS
''      OF THE ONBOARD DATA PROCESSING SYSTEM:
''          JOB 2 - GN&C GENERAL PROCESSING
''          JOB 3 - GN&C SOPS, MONITORING, AND CHECKING
''          JOB 4 - GN&C SEQUENCING, INTERFACES, AND FDI PROCESSES
''          JOB 5 - SYSTEM CONTROL AND USER INTERFACE.
''
''  JOB       TASK      PRIORITY     NATURE    GO/NOGO    PREDECESSORS
''                     RELATV ABSOL (CYCLIC)  VARIABLE
''
''            STIG              32
 i   2          6       10              2         401
```

```
''          ST2G                33
 1   2        7      10          2      401
''
''          OING                34
 1   2        8      10          2      401
''
''          ASNV                38
 1   2       15      14          2      401
''
''          AUPP                40
 1   2       19      15          2      401
''
''          ADAP                166
 1   2       36      44          2      401
''
''          IMUP                NA
''   2       38       0          2      401
''
''          ORGP                134
 1   3       40      38          2      401
''
''          SRGP                136
 1   3       41      39          2      401
''
''          AASP                100
 1   3       42      26          2      401
''
''          RASP                52
 1   3       45      19          2      401
''
''          BFFP                50
 1   3       49      18          2      401
''
''          AEAP                128
 1   3       50      36          2      401
''          HYSP                110
 1   2       52      30          2      401
''
''          THCP                67
 1   3       54      25          2      401
''
''          MTVP                140
 1   3       60      40          2      401
''
''          STVP                142
 1   3       62      41          2      401
''
''          OTVP                144
 1   3       64      41          2      401
''
''          OTFP                146
```

1	3	65	42		2	401
"						
"		MPSD		44		
1	4	70	17		2	401
"						
"		SFIL		NA		
"	4	71	0		2	401
"						
"		IMRM		NA		
"	4	72	0		2	401
"						
"		RCSF		112		
1	4	91	31		2	401
"						
"		OMSF		102		
1	4	92	27		2	401
"						
"		BFFD		30		
1	4	95	8		2	401
"						
"		ATTP		122		
1	2	97	34		2	401
"						
"		OMQM		21		
1	3	101	4		2	401
"						
"		RCQM		23		
1	3	102	5		2	401
"						
"		GAXI		25		
1	4	110	6		2	401
"						
"		RSLS		68		
1	4	114	25		2	401
"		SRSS		162		
1	4	115	44		2	401
"						
"		ETSS		164		
1	4	116	44		2	401
"						
"		SMEM		106		
1	3	119	28		2	401
"						
"		SRBM		108		
1	3	120	29		2	401
"						
"		ASNS		NA		
"	4	139	0		2	401
"						
"		VNTS		46		
1	4	161	17		2	401

```
''          RNGS                113
 1   4      164       32              2       401
''
''          MOPS                172
 1   2      165       46              2       401
''
''          ASAI                36
 1   2      168       12              2       401
''
''          RHCP                62
 1   3      171       23              2       401
''
''          GCSI                124
 1   4      175       35              2       401
''
''          ASDP                150
 1   2      176       42              2       401
''
''          GSWP                60
 1   2      180       21              2       401
''
''          SMEP                170
 1   3      181       45              2       401
''
''          OMFS                152
 1   4      182       43              2       401
''
''          OMIC                48
 1   4      183       17              2       408
''
''          OASC                114
''   3      18'       32              2       401
''          SRSC                118
 1   3      188       32              2       401
''
''          ARCP                116
 1   3      190       32              2       401
''
''          EDFP                115
 1   3      193       32              2       401
''
''          AUPS                12
 1   2      197        2              2       401
''
''          IDAP                130
 1   2      201       37              2       401
''
''          SRDA                120
 1   2      203       33              2       401
''
''          ADIP                6
```

1	2	206	0		2	401
''						
''		AMDP		8		
1	2	210	0		2	401
''						
''		GEFC		178		
1	2	306	48		2	401
''						
''		SSIP		180		
1	5	307	49		2	401
''						
''		GMIN		176		
1	2	309	47		2	401
''						
''		IMMC		31		
1	2	319	9		2	401
''						
''		MCDS		35		
1	5	332	11		2	401
''						
''		LDBP		65		
1	5	333	23		2	401
''						
''		USIF		55		
1	5	334	19		2	401
''						
''		CDIP		10		
1	5	335	1		2	401
''						
''		GPSW		19		
1	5	337	3		2	401

5 2 3 3 2 Tasks Each of the 59 scheduled processes (Principal Functions) of the DDPS which are relevant to the Ascent phase of the Orbital Flight Test was defined as an IMSIM task through use of the form 2 The tasks were referenced in the definition of DDPS jobs as described in the preceding section All tasks were assigned to "service class" 1 to permit interruption on the basis of priority. The "delay" field indicated for form 2 is not relevant to class 1 tasks, but must be filled in as a place-keeper (0 is used)

The DDPS process modules which are executed in a GPC were defined as "routines" as described in section 5 2 3.3 3 Each module is called for execution in one or more processes, and the analog in the DDPS model is a listing of routines as "Required Elements" of a task The 5-digit numbers listed for each task (see the form 2 printout following) indicate the type of element and the individual of that type to be included for execution of the task. If the first digit is 3, the remaining digits identify a routine, if it is 5, the remaining digits identify a message (see section 5.2 3.3.4).

Note that the amount of computation involved in performing a process was not directly associated with the tasks which represent the process, but rather with the routines which were employed for the task.

The scripted inputs for these tasks on IMSIM Specification form 2 were as follows

```
''ASCENT FIRST STAGE GUIDANCE -ST1G  (EVENT 19 TO EVENT 28)
''EXECUTED AT 160 MS INTERVALS AT SRB IGNITION IN MM102, AND REDUCED TO
''500 MS INTERVALS AFTER TOWER CLEARANCE (EVENT 21)
''4.1     CLASS    DELAY     REQUIRED ELEMENTS
 2   6      1        0       30171  1
''
''ASCENT SECOND STAGE GUIDANCE - ST2G   (EVENT 28 TO EVENT 32)
''EXECUTED AT 2000 MS INTERVALS AT START OF MM103 UNTIL MECO CMD
''(EVENT 32)
''4.2     CLASS    DELAY     REQUIRED ELEMENTS
 2   7      1        0       30171  1
''
''ORBIT INSERTION GUIDANCE - OING (EVENT 36 TO EVENT 44, EVENT 45
''TO EVENT 49)
''EXECUTED AT 2000 MS INTERVALS DURING MM104 AND GUIDANCE PHASE OF MM105
''4.3     CLASS    DELAY     REQUIRED ELEMENTS
 2   8      1        0       30156  30171  1
''
''ASCENT NAVIGATION - ASNV
''EXECUTED AT 4000 MS INTERVALS AT START OF NAV INIT (EVENT 14) IN MM101
''THROUGH MM106
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  15     1        0       30215  30013  1
''
''ASCENT USER PARAM PROCESSING - AUPP
''EXECUTED AT 2000 MS INTERVALS FROM EVENT 14 IN MM101, THEN
''EXECUTED AT 160 MS INTERVALS IN MM102 FROM SRB IGNITION CMD (EVENT 19)
''TO TOWER CLEAR (EVENT 21), AT 500 MS INTERV FROM TOWER CLEAR TO SRB
''SEP CMD (EVENT 28), AT 2000 MS INTERVALS IN MM103 FROM SRB SEP TO
''V GR/EQ Y (EVENT 31), AT 500 MS INTERV FROM V GR/EQ Y TO MECO CMD
''(EVENT 32), AT 2000 MS INTERV IN MM104, MM105, AND MM106, EXCEPT NO
''PROC DURING MODE TRANSITION FROM MM104 TO MM105 WHEN GUID INIT
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  19     1        0       30212  1
''
''AERO-JET DIGITAL AUTOPILOT - ADAP
''EXECUTED AT 40 MS INTERVALS IN MM103 FROM MECO CMD (EVENT 32) TO
''ET SEP CMD (EVENT 34).
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  36     1        0       30204  30207  30219  1
''
''IMU INERTIAL PROCESSING - IMUP
''*** ASSUME ACCURATE REPRESENTATION BY 20309 AND 20319
''        CLASS    DELAY     REQUIRED ELEMENTS
''  38
```

```
''ORBITER RATE GYRO SOP - ORGP
''EXECUTED AT 40 MS INTERVALS DURING MM101 THRU MM106
''         CLASS    DELAY     REQUIRED ELEMENTS
 2  40      1        0         30159  30011  50022  50023  1
''
''SOLID ROCKET BOOSTER RATE GYRO SOP - SRGP
''EXECUTED AT 40 MS INTERVALS DURING MM101 & MM102
''         CLASS    DELAY     REQUIRED ELEMENTS
 2  41      1        0         30159  30011  50022  50023  1
''
''ACCELEROMETER ASSEMBLY SOP - AASP
''EXECUTED AT 40 MS INTERVALS DURING MM101 AND MM102
''         CLASS    DELAY     REQUIRED ELEMENTS
 2  42      1        0         30159  30011  50006  50007  1
''
''RADAR ALTIMETER SOP - RASP
''EXECUTED AT 160 MS INTERVALS FROM ET SEPCMD (EVENT 34) IN MM103 TO
''TRANSITION TO MM104 (EVENT 36)
''         CLASS    DELAY     REQUIRED ELEMENTS
 2  45      1        0         30306  30011  50008  50009  1
''
''BODYFLAP POSITION FEEDBACK SOP - BFFP
''EXECUTED AT 160 MS INTERV DURING MM101 THRU MM104 UNTIL MPS DUMP
''COMPLETE (EVENT 43A)
''         CLASS    DELAY     REQUIRED ELEMENTS
 2  49      1        0         30159  30011  50046  50047  1
''
''AEROSURFACE ACTUATOR CMD SOP - AEAP
''EXECUTED AT 40 MS INTERVALS DURING MM101 THRU MM104 UNTIL MPS DUMP
''COMPLETE (EVENT 43A).
''         CLASS    DELAY     REQUIRED ELEMENTS
 2  50      1        0         30163  50053  1
''
''HYDRAULIC SYSTEM SOP - HYSP (EVENT 4 TO EVENT 43A)
''EXECUTED AT 40 MS INTERVALS FROM APUS ON AND SLEW CHECK CMD
''IN MM101 UNTIL MPS DUMP COMPLETE IN MM104.
''         CLASS    DELAY     REQUIRED ELEMENTS
 2  52      1        0         30159  50022  50023  1
''
''TRANSLATION HANDCONTROLLER SOP - THCP
''EXECUTED AT 80 MS INTERVALS STARTING AT MECO (EVENT 33) IN MM103 THRU
''MM106
''         CLASS    DELAY     REQUIRED ELEMENTS
 2  54      1        0         30159  1
''
''MPS THRUST VECTOR CONTROL COMMAND SOP - MTVP
''EXECUTED AT 40 MS INTERVALS DURING MM101 THRU MM104
''UNTIL MPS DUMP COMPLETE (EVENT 43A)
''         CLASS    DELAY     REQUIRED ELEMENTS
 2  60      1        0         30162  50064  50065  50066  50067  1
```

```
''SRB THRUST VECTOR CONTROL COMMAND SOP - STVP
''EXECUTED AT 40 MS INTERVALS DURING MM101 & MM102
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  62      1        0       30162  50064  50065  50066  50067  1
''
''OMS THRUST VECTOR CONTROL COMMAND SOP - OTVP
''EXECUTED AT 40 MS INTERVALS FROM MECO (EVENT 33) IN MM103 TO OMS
''CUTOFF (EVENT 42A) IN MM104 AND FROM GUIDANCE INIT (EVENT 45) TO OMS
''CUTOFF (EVENT 48A) IN MM105.
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  64      1        0       30162  50064  50065  50066  50067  1
''
''OMS TVC FEEDBACK SOP - OTFP
''EXECUTED AT 40 MS INTERVALS FROM MECO (EVENT 33) IN MM103 TO OMS
''CUTOFF (EVENT 42A) IN MM104 AND FROM GUIDANCE INIT (EVENT 45) TO
''OMS CUTOFF (EVENT 48A) IN MM105
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  65      1        0       30159  50040  50041  1
''
''MPS DUMP SEQUENCER - MPSD (EVENT 33A TO EVENT 43A)
''EXECUTED AT 160 MS INTERVALS AFTER MECO+ X SEC IN MM103 UNTIL MPS
''DUMP COMPLETED IN MM104
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  70      1        0       30177  50022  50023  50064  50065  50066 *
                             50073  1
''
''SELECTION FILTERING - SFIL
''***REPRESENTED AS ROUTINE 30011
''        CLASS    DELAY     REQUIRED ELEMENTS
''  71
''
''IMU REDUNDANCY MANAGEMENT - IMRM
''***REPRESENTED AS ROUTINE 30166
''        CLASS    DELAY     REQUIRED ELEMENTS
''  72
''
''REACTION CONTROL SYSTEM FDI - RCSF
''EXECUTED AT 40 MS INTERVALS
''***ASSUME WRITE TO CLOSE VALVES ONLY IF FAULT INDICATED (LEAK OR
''   RUNAWAY THRUSTER)
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  91      1        0       30214  50006  50007  50022  50023  50038 *
                             50039  50046  50047  50064  50065  50066 *
                             50067  50079  50080  50081  50082  1
```

```
''ORBITAL MANEUVERING SYSTEM FDI - OMSF
''EXECUTED AT 40 MS INTERVALS FROM OMS IGNITION CMD IN MM101
''(EVENT 37) THRU REMAINDER OF MM104 (EVENT 44) AND FROM OMS
''IGNITION CMD IN MM105 (EVENT 46) THRU REMAINDER OF MM105 (EVENT 49)
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  92      1        0       30214  1
''
''BODY FLAP COMMAND FDIR - BFFD (EVENT 1 TO EVENT 43A)
''EXECUTED AT 320 MS INTERVALS DURING MM101 THRU MM104, UNTIL MPS
''DUMP COMPLETE.
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  95      1        0       30213  1
''
''ATTITUDE PROCESSING - ATTP
''EXECUTED AT 40 MS INTERVALS P.QUATERNION AT NAV INITIATION (EVENT 14)
''IN ALL MM
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  97      1        0       30210  1
''
''ORBITER MANEUVERING SYSTEM QUANTITY MONITOR - OMQM
''EXECUTED AT 1000 MS INTERVALS
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 101      1        0       30159  50046  50047  50024  50025  50026 *
                             50027  1
''
''REACTION CONTROL SYSTEM QUANTITY MONITOR - RCQM
''EXECUTED AT 1000 MS INTERVALS
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 102      1        0       30159  50026  50027  50012  50013  50050 *
                             1
''
''GN&C ANNUNCIATION INTERFACE - GAXI
''EXECUTED AT 1000 MS INTERVALS
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 110      1        0       30159  50042  50043  50046  50047  50012 *
                             50013  50022  50023  50024  50025  50026 *
                             50027  1
''
''REDUNDANT SET LAUNCH SEQUENCE PROCESSING - RSLS
''EXECUTED AT 80 MS INTERVALS DURING MM101
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 114      1        0       30176  50024  50025  50026  50027  50064 *
                             50065  50066  50067  50069  50070  50071 *
                             50072  1
''
''SRB SEPARATION SEQUENCER - SRSS (EVENT 25 TO EVENT 28)
''EXECUTED AT 40 MS INTERVALS IN MM102 WHEN MET GR/EQ X SEC
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 115      1        0       30177  50022  50023  50069  50070  50071 *
                             50072  1
```

```
''EXTERNAL TANK SEPARATION SEQUENCER - ETSS (EVENT 33 TO EVENT 36)
''EXECUTED AT 40 MS INTERVALS IN MM103 AFTER MECO
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 116      1        0       30177  50042  50043  50069  50070  50071 *
                             50072  50084  50085  1
''
''SS MAIN ENGINE MONITOR FUNCTION - SMEM (EVENT 4 TO EVENT 43A)
''EXECUTED AT 40 MS INTERVALS FROM APUS ON AND SLEW CHECK CMD
''IN MM101 UNTIL MPS DUMP COMPLETE IN MM104.
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 119      1        0       30159  50046  50047  1
''
''SRB MONITOR FUNCTION - SRBM (EVENT 1 TO EVENT 28)
''EXECUTED AT 40 MS INTERVALS DURING MM101 AND MM102
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 120      1        0       30159  30011  50022  50023  50046  50047 *
                             1
''
''ASCENT NAVIGATION SEQUENCER - ASNS
''***REPRESENTED AS ROUTINE 30013
''        CLASS    DELAY     REQUIRED ELEMENTS
'' 139
''
''VENT DOOR CONTROL SEQUENCER - VNTS
''EXECUTED AT 160 MS INTERVALS WHEN TBO = -6.1 SEC (EVENT 13)
''UNTIL DOORS CLOSE, AND WHEN MET GR/EQ 10 SEC (EVENT 22) UNTIL
''DOORS OPEN
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 161      1        0       30177  50064  50065  50066  50067  50079 *
                             50080  50081  50082  1
''
''RANGE SAFETY - RNGS
''EXECUTED AT 40 MS INTERVALS WHEN MET GR/EQ X SEC (EVENT 24)
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 164      1        0       30177  50069  50070  50071  50072  1
''
''SSME OPERATIONS - MOPS (EVENT 19 TO EVENT 34)
''EXECUTED AT 40 MS INTERVALS IN MM102 AND MM103 UNTIL ET SEP CMD
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 165      1        0       30216  50046  50047  50064  50065  50066 *
                             1
''
''ASCENT ATTITUDE DIRECTOR INDICATOR PROCESSOR - ASAI
''EXECUTED AT 160 MS INTERVALS FOR PROCESSING AND AT 960 MS INTERVALS
''FOR SWITCHES STARTING AT NAV INITIATION (EVENT 14)
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 168      1        0       30304  50054  1
```

```
''THREE AXIS RHC SOP - RHCP
''EXECUTED AT 80 MS INTERVALS STARTING AT ET SEPARATION (EVENT 34)
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 171      1        0       30211  30011  50038  50039  1
''
''GUIDANCE/CONTROL STEERING INTERFACE - GCSI (EVENT 19 TO EVENT 50)
''EXECUTED AT 40 MS INTERVALS IN MM102 THRU MM106
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 175      1        0       30206  1
''
''ASCENT DIGITAL AUTOPILOT - ASDP
''EXECUTED AT 40 MS INTERVALS AFTER ORB/FCS VERIF (EVENT 5) IN MM101
''UNTIL MECO (EVENT 33) IN MM103
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 176      1        0       30183  30207  30204  30202  30203  1
''
''GN&C SWITCH PROCESSOR - GSWP
''EXECUTED AT 80 MS INTERVALS DURING ALL MAJOR MODES
''*** ASSUME FF DISCRETES CORRESPOND TO SWITCHES AND PANEL SWITCHES
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 180      1        0       30159  50006  50007  50038  50039  1
''
''SS MAIN ENGINE SOP - SMEP
''EXECUTED AT 40 MS INTERVALS UNTIL MPS DUMP COMPLETE (EVENT 43A) IN
''MM104
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 181      1        0       30181  30220  50034  50035  50061  50062 *
                             50050  50063  1
''
''OMS FIRING SEQUENCER - OMFS
''EXECUTED AT 40 MS INTERVALS FROM OMS IGNITION (EVENT 37) TO OMS CUTOFF
''(EVENT 42A) IN MM104
''EXECUTED AT 40 MS INTERVALS FROM OMS IGNITION (EVENT 46) TO OMS CUTOFF
''(EVENT 48A) IN MM105
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 182      1        0       30185  50053  1
''
''OMS-TO-OMS INTERCONNECT - OMIC
''EXECUTED AT 160 MS INTERVALS WHEN OMS ENGINE FAILURE IN -
''MM104 (EVENT 40A/B TO EVENT 42A),
''MM105 (EVENT 46A/B TO EVENT 48A).
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 183      1        0       30186  50053  50046  50047  1
''
''ORB ACTUATOR SLEW CHECK - OASC (EVENT 4 TO EVENT 5)
''EXECUTED AT 40 MS INTERVALS DURING ORB/FCS VERIF IN MM101
''        CLASS    DELAY     REQUIRED ELEMENTS
'' 187
```

```
''SRB ACTUATOR SLEW CHECK - SRSC (EVENT 8 TO EVENT 8A)
''EXECUTED AT 40 MS INTERVALS DURING SRB/FCS VERIF IN MM101
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 188      1        0       30188  1
''
''ASCENT RCS COMMAND SOP - ARCP
''EXECUTED AT 40 MS INTERVALS STARTING AT FCS TVC RETRIM (EVENT 32)
''IN MM103 THRU MM106.
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 190      1        0       30218  50064  50065  50066  50067  50079 *
                             50080  50081  50082  1
''
''ELEVON DELTA PRESSURE FEEDBACK SOP - EDFP (EVENT 19 TO EVENT 28)
''EXECUTED AT 40 MS INTERVALS DURING MM102
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 193      1        0       30159  30011  50046  50047  1
''
''ASCENT/USER PARAM PROCESSING SEQUENCER - AUPS
''EXECUTED AT 2000 MS INTERVALS STARTING AT NAV INITIATION (EVENT 14)
''IN MM101 THRU MM106
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 197      1        0       30014  1
''
''INSERTION DIGITAL AUTOPILOT - IDAP
''EXECUTED AT 40 MS INTERVALS STARTING AT ET SEP (EVENT 34) IN MM103
''THRU MM106.
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 201      1        0       30204  30183  30203  30170  1
''
''SRB DATA ACQUISITION - SRDA (EVENT 1 TO EVENT 28)
''EXECUTED AT 40 MS INTERVALS IN MM101 AND MM102
''DATA FOR DOWNLIST
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 203      1        0       30159  50044  50045  1
''
''ASCENT DISPLAY PROCESSING - ADIP (EVENT 1 TO EVENT 36)
''EXECUTED AT 2000 MS INTERVALS IN MM101, MM102, AND MM103 TO EVENT 31
''(MECO MON), THEN AT 500 MS INTERVALS TO END OF MM103.
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 206      1        0       30221  1
''
''ASCENT MANEUVER DISPLAY PROCESSING - AMDP (EVENT 36 TO EVENT 50)
''EXECUTED AT 2000 MS INTERVALS IN MM104, MM105, AND MM106
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 210      1        0       30221  1
```

```
''FAST CYCLE EXECUTIVE - GEFC
''EXECUTED AT 40 MS INTERVALS
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 306      1        0       30301  50010  50020  50021  50052  50011 *
                             1
''SYSTEM SOFTWARE INTERFACE PROCESSOR - SSIP
''EXECUTED AT 40 MS INTERVALS
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 307      1        0       30116  50028  50029  50058  1
''
''MINOR CYCLE EXECUTIVE - GMIN
''EXECUTED AT 40 MS INTERVALS
''NOTE IMU REFERENCE UPDATE AT EVENT 11
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 309      1        0       30045  30303  30166  1
''
''IMU MAJOR CYCLE EXECUTIVE - IMMC
''EXECUTED AT 320 MS INTERVALS
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 319      1        0       30309  30305  30166  1
''
''MCDS INPUT PROCESSOR - MCDS
''EXECUTED AT 200 MS INTERVALS
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 332      1        0       30148  30149  1
''
''LDB I/O PROCESSOR - LDBP
''EXECUTED AT 40 MS INTERVALS DURING MM101
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 333      1        0       30136  30149         1
''
''USER INTERFACE CONTROL - USIF
''EXECUTED ON DEMAND
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 334      1        0       30313  50059  50060  1
''
''CYCLIC DISPLAY PROCESSING - CDIP
''EXECUTED AT 100 MS INTERVALS
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 335      1        0       30314  50055  50056  50057  1
''
''GPC SWITCH MONITOR - GPSW
''EXECUTED AT 1000 MS INTERVALS
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 337      5        0       30159  1
```

5 2.3.3 3 Routines The program modules which are called for DDPS processes are represented as IMSIM "routines". An IMSIM form 3 is used to define each routine As a practical consideration, a one-one correspondence between routines and modules was not maintained, instead, modules which are collectively employed for a process are grouped together and treated as a single routine. The conditions under which individual modules are exercised and the extent to which they perform computation is represented by segments of the "Computation Time" function associated with each routine. These functions are defined and discussed in section 5 2.1.4.

For each form 3 listed below, comments are included to indicate which modules were represented by the routine. If the routine is to be used for more than one task, the "Share" code must be 1; otherwise its value is irrelevant.

A number of fields of form 3 are not significant to simulation of the DDPS but must be filled with acceptable values for proper operation of IMSIM. Thus: a "Library Data Set" specified for reading of routines from some external source is given, although analysis of memory loading is not being conducted and the values are only nominal; the "Time" field indicates an optional cutoff of computation, and 0 indicates that no cutoff is desired, since there is only one class of processor being simulated (the CPU), it is nominally defined as a class 10, and finally, since there is only a single memory unit for each GPC, one GPC is simulated as the active transmitting computer while the other three are simulated as redundant. The memory is designated as a variable Function 444 which was set to 70001.

The scripted inputs for these routines on IMSIM Specification form 3 were as follows

```
''**** ROUTINES ***************************************************
''
''     EACH FUNCTION OR SET OF FUNCTIONS CALLED IN PERFORMANCE OF A
''     SCHEDULED TASK IS DEFINED AS A ROUTINE.  ROUTINE 1 IS RESERVED
''     FOR THE SIMULATION EXECUTIVE.  ROUTINES WITH NUMBERS GREATER
''     THAN 200 REPRESENT SETS OF FUNCTIONS.
''
''SELECTION FILTERING   (TASKS 40, 41, 42, 45, 49, 171, 193, 120)
''*** REPLACES 20071
''   SF
''      SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3  11   1    110001        1      0    10    444   441 0 0
''
''ASCENT NAVIGATION SEQUENCER FUNCTIONS   (TASK 15)
''   AS_NAV_SEQ
''   ASC_NAV_INIT     ASCENT NAVIGATION INITIATION
''      SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3  13   1    110001        1      0    10    444   325 0 0
''
''ASCENT/USER PARAMETER PROCESSING SEQUENCE (TASK 197)
''   ASC_UPP_SEQ
''      SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3  14   1    110001        1      0    10    444   326 0 0
```

```
''IMU PROCESSING   (TASK 309)
''   GMA_MIN_EXEC          IMU MINOR CYCLE EXECUTIVE
''   GMD_RES_PROC          IMU RESOLVER PROCESSOR
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3  45   1    110001       1      0    10    444   356 0 0
''
''SYSTEM SOFTWARE INTERFACE   (TASK 307)
''   AIE_SIP               SYSTEM INTERFACE PROCESSOR
''   DCD_DOWNLIST          GPC DOWNLIST FORMATTER
''   DIM_ICC_COLLECTOR     ICC MESSAGE COLLECTOR
''   DME_ICC_ROUT          ICC MESSAGE ROUTER
''   DMS_FMS               FAULT MESSAGE SCAN
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 116   0    110001      800      0    10    444   430 0.216 10
''
''LDB PROCESSING   (TASK 333)
''   DGI_LDB_IO            LDB I/O PROCESSOR
''   DLM_LDB_ROUT          LDB MESSAGE ROUTER
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 136   1    110001     3040      0    10    444   16 0.384 0
''
''MCDS INPUT PROCESSOR   (TASK 332)
''   DMI_MCDS_IN
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 148   0    110001      400      0    10    444   16 0.18 0
''MCDS MESSAGE PROCESSOR  (TASKS 332, 333)
''   DMM_MCDS_PROCESS
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 149   1    110001     2200      0    10    444   432  0  0
''
''MANEUVER TRIM DISPLAY SUPPORT (TASK 8)
'     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 156   1    110001       1      0    10    444    16 0.6 0
''
''DATA ACQUISITION, MONITORING AND FEEDBACK
''   ORB_RG_SOP                                              (TASK  40)
''   SRB_RG_SOP                                              (TASK  41)
''   AA_SOP                                                  (TASK  42)
''   ARA_GPC_SWITCH                                          (TASK 337)
''   BF_PFB_SOP                                              (TASK  49)
''   OMS_TVC_FB_SOP                                          (TASK  65)
''   OMS_QTY_MON                                             (TASK 101)
''   RCS_QTY_MON                                             (TASK 102)
''   GAX                                                     (TASK 110)
''   GN&C_SW_PROC                                            (TASK 180)
''   HYDR_SYS_SOP                                            (TASK  52)
''   THC_SOP                                                 (TASK  54)
''   SRB_DATA_ACQ                                            (TASK 203)
''   SSME_MON_FCN                                            (TASK 119)
''   SRB_MON_FCN                                             (TASK 120)
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
```

```
 3 159   1    110001        1      0    10    444   446 0 0
''
''THRUST VECTOR CONTROL CMD SOP   (TASKS 60, 62, 64)
''   MPS_TVC_CMD_SOP     (TASK 60)
''   SRB_TVC_CMD_SOP     (TASK 62)
''   OMS_TVC_CMD_SOP     (TASK 64)
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 162   1    110001        1      0    10    444   346 0 0
''
''AEROSURFACE ACTUATOR CMD SOP   (TASK 50)
''   AERO_ACT_SOP
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 163   1    110001        1      0    10    444   337 0.615 0
''
''IMU REDUNDANCY MGMT   (TASKS 309, 319)
''*** REPLACES 20072
''   IMU_RM
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 166   1    110001        1      0    10    444   16  0.14  0
''
''RCS COMMAND GENERATION   (TASK 201)
''   RCS_CG
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 170   1    110001        1      0    10    444   327 0 0
''COMPUTE STEERING CMDS   (TASKS 6, 7, 8)
''   AS_1STG_GUID   (TASK 6)
''   AS_2STG_GUID   (TASK 7)
''   ORB_INS_GUID   (TASK 8)
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 171   1    110001        1      0    10    444   328 0 0
''
''REDUNDANT SET LAUNCH PROCESSING SEQUENCE   (TASK 114)
''   R/S_LCH_SEQ   (REF. OFT 12, 4.1.1)
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 176   1    110001        1      0    10    444   341  0  0
''
''SEQUENCERS
''   SRB_SEP_SEQ       SRB SEPARATION                          (TASK 115)
''   ET_SEP_SEQ        EXTERNAL TANK SEPARATION                (TASK 116)
''   MPS_DUMP          MAIN PROPULSION SYSTEM DUMP             (TASK  70)
''   RNG_SAFETY        RANGE SAFETY FUNCTION                   (TASK 164)
''   VENT_CNTL_SEQ     VENT DOOR CONTROL                       (TASK 161)
''     SHARE  LIB DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 177   1    110001        1      0    10    444   340 0 0
''
''MAIN ENGINE SOP   (TASK 181)
''   SSME_SOP
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 181   1    110001        1      0    10    444   16 0.23 0
```

```
''FLIGHT CONTROL RECONFIGURATION   (TASKS 176, 201)
''   FC_RECON   (REF. OFT 5, 4.6.3)
''     INITIALIZATION
''     ANNUNCIATION
''     SUBPHASE_AND_MODING_INDICATORS
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 183   1    110001        1      0    10    444   329 0 0
''
''ORBITAL MANEUVERING SYSTEM FIRING SEQUENCE   (TASK 182)
''   OMS_FIRE_SEQ   (REF. OFT 12, 4.7.6)
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 185   1    110001        1      0    10    444   342  0  0
''
''OMS TO OMS INTERCONNECT FUNCTION   (TASK 183)
''   OMS/OMS_CONN
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 186   1    110001        1      0    10    444   16 0.279 0
''
''SOLID ROCKET BOOSTER ACTUATOR SLEW CHECK   (TASK 188)
''   SRB_SLEW
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 188   1    110001        1      0    10    444   16 0.384 0
''COMMAND PROCESSING  (TASK 176)
''   CMD_PROC_SRB   SOLID ROCKET BOOSTER  (REF. OFT 5, 4.6.4.4)
''     TRIM_MIX_SRB     TRIM MIXING LOGIC COMPUTATION            40 MS
''     BIAS_LIM_SRB_PREP CHAMBER PRESSURE PARAM CALCULATIONS     80 MS
''     BIAS_LIM_SRB     THRUST VECTOR DEFL. & ACTUATOR STROKE LIM40 MS
''     SRB_LIM_SUBRO    THRUST VECTOR DEFL & ACT.STR.LIMITING CAL
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
''   CMD_PROC_ORB   ORBITER  (REF. OFT 5, 4.6 4.3)
''     TRIM_MIX_ORB     TRIM MIX NOZZLE DEFLECTION COMP           40 MS
''     BIAS_LIM_ORB     BIAS COMP, STROKE & RATE LIMITS           40 MS
''     PRL_ORB          PRIORITY RATE LIMITATION CALC FOR STROKE 40 MS
''     PRL_ORB_SUBRO    ACTUATOR COMMANDS COMP. 3X FOR EACH SSME
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 202   1    110001        1      0    10    444   330  0  0
''
''THRUST VECTOR CONTROL LAWS  (TASKS 176, 201)
''   TVC_ORB_SRB   (REF. OFT 5, 4.6.4.2)
''     CMD_ROLL         ROLL THRUST VECTOR DEFL. COMMANDS COMP.
''     CMD_PITCH        PITCH THRUST VECTOR DEFL. COMMANDS COMP.
''     FB_S1C_PITCH     STAGE 1 PITCH RATE FEEDBACK ERROR COMP.
''     FB_S2C_PITCH     STAGE 2 PITCH RATE FEEDBACK ERROR COMP.
''     CMD_YAW          YAW THRUST VECTOR DEFLECTION COMP
''     FB_S1C_YAW       STAGE 1 YAW RATE FEEDBACK ERROR COMP
''     FB_S2C_YAW       STAGE 2 YAW RATE FEEDBACK ERROR COMP
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 203   1    110001        1      0    10    444   331 0 0
```

```
''LINEAR INTERPOLATION FUNCTIONS (TASKS 36, 176, 201)
''   INTERPS   (REF. OFT 5, 4.6.4.5)                                  160 MS
''     VREL_XTRAP       RELATIVE VELOCITY EXTRAPOLATION CALC
''     S1T_TRIMS_ACC    STAGE 1 TRIMS & ACCELERATION CALC
''     S2T_TRIMS        STAGE 2 TRIMS CALC
''     ELEV_SCHED       SCHEDULED ELEVON DEFLECTION COMP
''     TVC_GAINS        THRUST VECTOR CONTROL GAINS CALC.
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 204   1    110001        1      0    10    444   332  0  0
''
''GUIDANCE & CONTROL STEERING INTERFACE   (TASK 175)
''   GC_INTERF   (REF. OFT 5, 4.6.4.1)                              INTERVAL
''     DBCMDS_S2G       THRUST DIRECTION & BODY ROTAT.RATE COMP 480 MS
''     DBACCEL          ACCELLERATION & RATE LIMITING CALC      480 MS
''     DBQUAT           QUATERNION INTEGRATION CALC              40 MS
''     ATTERS           ATTITUDE ERRORS COMP                     40 MS
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 206   1    110001        1      0    10    444   440 0 0
''
''AEROSURFACE CONTROL FUNCTIONS   (TASKS 36, 176)
''   AEROSRF_CNTRL   (REF. OFT 5, 4.6.4.6)                          INTERVAL
''     BF_HYSTER          BODY FLAP DEADBAND/HYSTERESIS COMP   160 MS
''     ELVN_LD_REL        ELEVON LOAD RELIEF CALC               80 MS
''     ELVN_LD_REL_SUBRO  ELEVON LOAD RELIEF SUBROUTINE 2X      80 MS
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 207   1    110001        1      0    10    444   333 0 0
''ATTITUDE PROCESSING FUNCTIONS  (TASK 97)
''   ATT_PROC   (REF. OFT 5, 4.6.5)                                  INTERVAL
''     ATT_PROC_INIT    ATTITUDE PROCESSING INITIALIZATION        INIT
''     ATT_PROC_MODE_CHG ATTITUDE MODE CHANGE                     INIT
''     ATT_PROC_OUTER   OUTER LOOP PRECISION                      960 MS
''     ATT_PROC_INNER   INNER LOOP QUATERNION UPDATE               40 MS
''     ATT_PROC_ENTRY   ENTRY THRU LANDING ATTITUDE                NA
''     ATT_PROC_DISP    ATTITUDE DISPLAY                           40 MS
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 210   1    110001        1      0    10    444   343  0  0
''
''ROTATIONAL HAND CONTROLLER PROCESSING FUNCTIONS  (TASK 171)
''   3-AX_RHC_SOP   (REF. OFT 10, 4 171)
''     RHC_SOP_INIT     RHC SUBSYSTEM OPS PROG INITIATION
''     RHC_COMP         RHC COMPENSATION CALCULATIONS
''     RHC_DB           RHC DEADBANDING COMPUTATION
''     RHC_STA_SEL      RHC STATION SELECT CALC.
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 211   1    110001        1      0    10    444    16  0.2  0
''
''ASCENT USER PARAMETER PROCESSING   (TASK 19)
''   ASC_UPP
''   ASC_UPP_INIT     USER PARAM PROCESSING INITIATION
''   ASC_Q_BAR_INIT   DYNAMIC PRESSURE CALCULATIONS
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 212   1    110001        1      0    10    444   334 0 0
```

```
''BODY FLAP COMMAND FDIR (TASK 95)
''   BF_CMD_FDIR
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 213   1    110001        1      0    10    444    16 0.04 0
''
''FAULT DETECTION AND ISOLATION   (TASKS 91, 92)
''   OMS_FDI                                                    (TASK  92)
''   RCS_FDI                                                    (TASK  91)
''      AVAIL_JET_STAT   AVAILABLE JET STATUS COMPUTATIONS
''      JET_FAIL_OFF     JET FAILURE MONITOR CALC
''      JET_FAIL_ON      JET FAILURE MONITOR CALC #2
''      JET_LEAK         JET LEAKAGE MONITOR CALC
''      MANIF_STAT       MANIFOLD STATUS MONITOR CALC
''      JET_FAULT_LIM    JET FAULT LIMIT CALC.
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 214   1    110001        1      0    10    444   344  0  0
''ASCENT NAVIGATION   (TASK 15)
''   ASC_NAV
''     SNAP_IMU
''     NAV_STATE_PROP         NAV STATE PROPAGATION
''     COVEXTRAP_PF           COVARIANCE MATRIX PROPAGATION
''     MAN_ST_COV_SETUP       MANUAL STATE & COVARIANCE SETUP
''     THREE_TO_ONE_STATE
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 215   1    110001        1      0    10    444   335 0 0
''
''MAIN ENGINE OPERATIONS   (TASK 165)
''   SSME_OPS
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 216   1    110001        1      0    10    444   336 0 0
''
''ASCENT REACTION CONTROL SYSTEM PROCESSING  (TASK 190)
''   AS_RCS_CMD_SOP   (REF. OFT 11, 4.190)
''     RCS_CMD_GEN          RCS COMMAND GENERATION PROC
''     RCS_INH_FIR          RCS INHIBIT THRUSTER FIRING PROC
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 218   1    110001        1      0    10    444   345 0 0
''
''AERO-JET DIGITAL AUTOPILOT   (TASK 36)
''   AERO-JET-DAP                                  INTERVAL
''     AERO_RECON       RECONFIGURATION             80 MS
''     PRL              PRIORITY RATE LIMITING      40 MS
''     JSL              JET SELECTION               NA
''     BK_CHNL          BANK CHANNEL                40 MS
''     P_CHNL           PITCH CHANNEL               40 MS
''     NW_CHNL          NOSEWHEEL CHANNEL           NA
''     SB_CHNL          SPEEDBRAKE CHANNEL          NA
''     BF_CHNL          BODY FLAP CHANNEL           NA
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 219   1    110001        1      0    10    444  405 2.34 0.29
```

```
''THROTTLE CONTROL FUNCTIONS   (TASK 181)
''   THROT_XTRAP      FIRST ORDER EXTRAP IN S2G
''     (REF. OFT 5, 4.6.4.7)                                        80 MS
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 220   1    110001        1      0    10    444   449 0 0
''
''GN&C DISPLAY PROCESSING   (TASKS 206, 210)
''   ASC_DIP        ASCENT                                        (TASK 206)
''   ASC_MNVR_DIP   ASCENT MANEUVER                               (TASK 210)
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 221   1    110001        1      0    10    444   448 0 0
''
''FLIGHT CONTROL   (TASK 306)
''   GEF_FC_EXEC          FAST CYCLE EXECUTIVE
''   GKF_FC_KIP           FC KEYBOARD INTERFACE PROCESSING
''OTHER PROCESSORS ARE DISTRIBUTED AMONG THE OTHER PRINCIPAL FUNCTIONS.
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 301   1    110001        1      0    10    444   350 0.025 0
''IMU BITE PROCESSING, ACCELEROMETER ACCUMULATOR, & GYRO TORQUING
''(TASK 309)
''   GMB_IMU_BITE        IMU BITE PROCESSING
''   GMC_ACP_ACUM        ACCELEROMETER PROCESSING
''   GMF_GYO_TORQ        GYRO TORQUE PROCESSING
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 303   1    110001        1      0    10    444   362 0 0
''
''DISPLAYS AND IMU MODING   (TASK 168)
''   GDA_DED_DISP_PROC   DEDICATED DISPLAY PROCESSOR
''   GDB_AVVI_AMI_PROC   DEDICATED DISPLAY, AVVI, AMI PROCESSOR
''   GDE_ADI_PROC        DEDICATED DISPLAY ADI PROCESSOR 160MS(TASK 168)
''   GDF_HSI_PROC        DEDICATED DISPLAY HSI PROCESSOR
''   GDZ_DISP_PROC       CRT DISPLAY PROCESSOR
''   GMN_IMU_MODING      IMU MODING
''   IMU_BITE_SUM        IMU BITE SUMMARY
''   GPC_AD_CALC         AIR-DATA CALCULATIONS
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 304   1    110001        1      0    10    444   390 0 0
''
''IMU GYRO AND ACCELEROMETER FUNCTIONS   (TASK 319)
''   GMH_ACP_COMP        IMU ACCELEROMETER COMPENSATION
''   GML_ACP_TRSF        IMU ACCELEROMETER PULSE TRANSFORMATION
''   GMK_GYO_COMP        IMU GYRO COMPENSATION
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 305   1    110001        1      0    10    444    16 1.344 0
''
''NAVIGATION   (TASK 45)
''   GNA_MLS_MEAS        MSBLS MEASUREMENT PROCESSING
''   GNB_TACAN_MEAS      TACAN MEASUREMENT PROCESSING
''   GNC_BARO_ALT        BARO-ALTIMETER MEASUREMENT PROCESSING
''   GND_RADAR_ALT       RADAR-ALTIMETER MEASUREMENT        (TASK 45)
```

```
''   GNE_NAV_EXEC          NAVIGATION EXECUTIVE
''   GN1_DATA_SNAP         DATA SAVING
''   GN3_MEAS_SCHDLR       MEASUREMENT SCHEDULER
''   GN7_NAV_FILTER        FILTER
''     SHARE  LIB.DS       SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 306   1    110001         1      0    10     444   368 0.15 0
''
''IMU MAJOR FUNCTIONS    (TASK 319)
''   GMG_MAJ_EXEC          MAJOR CYCLE EXECUTIVE
''   GMI_T_UPDATE          TRANSFORM UPDATE
''   GMJ_TOR_TRSF          TORQUING TRANSFORM
''   GMM_LAT_FUNC          LARGE ANGLE TORQUING
''   GMQ_LSF_FILR          LEAST SQUARES FILTER
''     SHARE  LIB.DS       SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 309   1    110001         1      0    10     444   353  0  0
''USER INTERFACE SUPERVISOR   (TASK 334)
''   DMC_SUPER             USER INTERFACE CONTROL SUPERVISOR
''   DMC_FUNCTIONS         KEYBOARD FUNCTIONS
''   DMC_APP_INT           APPLICATION CONTROL INTERFACE
''   DMC_MCDS_CNT          MCDS DISPLAY CONTROL
''   DMC_APP_KEY_PROCESS   APPLICATION KEYS PROCESSING
''   DMC_DISPLAY           DISPLAY COORDINATION
''   DMC_NEW_DISPLAY       NEW DISPLAY PROCESSING
''   DMC_SEQ_REQ_PROC      SEQUENCE REQUEST PROCESSING
''   DIM_ICC_COLLECTOR     ICC MSG COLLECTOR
''     SHARE  LIB.DS       SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 313   0    110001       10380     0    10     444   431  0  0
''
''CYCLIC DISPLAY PROCESSING   (TASK 335)
''   DCI#CYC               CYCLIC DISPLAY PROCESSING
''   DCI#CON               DATA CONVERSION
''   DCI#FMT               DATA FORMATTING
''     SHARE  LIB.DS       SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 314   0    110001       5252      0    10     444 435 2.06 8.3
```

5 2 3 3 4 Messages All data transmissions performed by the IOP of the GPC being simulated were defined as messages using IMSIM form 5 Other transmissions were not simulated as they have no impact on loading of the GPC under study, i.e., they did not occupy resources of the GPC and, due to the configuration of the DDPS, could not interfere with transmissions controlled by the GPC.

Each "read" transmission is preceded by a "write" transmission to query the appropriate device Although a message defined via form 5 represents a type of transmission, it may represent one or more occurrences of the transmission, each with different source, destination, length, etc These capabilities are employed in characterizing DDPS transmissions for the model, and are best illustrated by example Consider the pair of message definitions 6 and 7 as shown in the list of forms following (the first two lines which begin with the

number 5). As indicated by the "total" field, each of these messages represents three transmissions. Message 6 represents a sequence of write transmissions (from memory 1, denoted by 70001) to a destination denoted by V380. This variable is described in section 5.2.1.5; in essence, it states that the destination for the first (of three) transmission is Multiplexer/Demultiplexer for the Flight Critical Forward Instruments #3 (60011), that the second is Multiplexer/Demultiplexer for the Flight Critical Forward Instruments #2 (60010), and that the third is Multiplexer/Demultiplexer for Flight Critical Forward Instruments #1 (60009).

The Length and Interval fields are each comprised of three subfields: the value 16 in the first subfield denotes a constant length (2 characters) or interval (0 ms), as indicated by the second subfield (the third subfield is not used for the DDPS model) Length is expressed in terms of 8-bit characters of data transmitted, and transmission rates for hardware (as described in section 5.2.3 2) are adjusted to compensate for the added control bits of each transmission. The Nature of message 6 is given as 0--indicating that it can only be initiated when the task has been activated--and 0 in the Start column causes the first transmission to be initiated immediately after the task commences.

Message 7 represents the response to message 6, and its transmission is correlated on a one-one basis with transmission of message 6 by giving the source of the message as message 6 (50006). Note that in this situation, transmission of message 7 is triggered by completion of a message 6 transmission, and the source for message 7 is taken to be the sink of message 6 Message transmissions are simulated whenever a task is activated which includes the message among its required elements (see section 5 2.3 3 2). Interference in accessing system components for transmission is automatically handled by IMSIM according to hardware and configuration specifications included in forms 6 through 12.

The scripted inputs for these messages on IMSIM Specification form 5 were as follows

```
''READ FROM FF01,2,3
''   ACCELEROMETER ASSEMBLY (FWD ACCEL)                    F*(TASK  42)
''   RCS VALVE STATUS (MCA)                                  (TASK  91)
''   THC POS/NEG X/Y/Z (AFT/LH THC)                        D (TASK 180)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5   6   0     70001    380  16  2 0     16  0 0     0      3
 5   7   0     50006  70001 361  0 0    360  0 0     0      3  0  2
''
''READ FROM FF01,2   (TASK 45)
''   RALT WORD (RADAR ALTM1,2)                             F*(TASK 45)
''   RALT WORD (RADAR ALTM1,2)                             D*(TASK 45)
''     NATURE  SOURCE  SINK  LENCTH      INTERVAL   START  TOTAL
 5   8   0     70001    380  16  2 0     16  0 0     0      2
 5   9   0     50008  70001  16  4 0    360  0 0     0      2
''
''READ FROM FF01,2,3   (TASK 306)
''   IMU                                                        (TASK 306)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
```

```
 5  10   0      70001     380  16  2 0      16  0 0       0       3
 5  11   0      50010   70001  16 32 0     360  0 0       0       3
''
''READ FROM FF01,3   (TASKS 102, 110)
''   RCS PROP TANK PRESSURES (OF2 DED SIG CON, DSC 0F4)   -
''                                                        F*(TASKS 102, 110)
''   RCS PROP TANK TEMPS (DSC OF4, OF2 DED SIG CON)        F*(TASK 102)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  12   0      70001     357  16  4 0      16  0 0       0       2
 5  13   0      50012   70001  16 28 0     360  0 0       0       2  0  2
''
''READ CLOCK (MTU) FROM FF01,2,3   (TASK 306)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  20   0      70001     380  16  2 0      16  0 0       0       3
 5  21   0      50020   70001  16 18 0     360  0 0       0       3
''
''READ FROM FA01,2,3
''   HYDRAULIC SUPPLY PRESSURES (D&C PNL F08A8)             F*(TASK  52)
''   ORB RATE GYRO ASSEMBLY (RGA)                          DF*(TASK  40)
''   SRB RATE GYRO ASSEMBLY (LH/RH SRB RGA)                 F*(TASK  41)
''   SRM CHAMBER PRESSURES (LH/RH SRB)                     F*(TASKS 120, 115)
''   RCS PROPELLANT TEMPS (OA1,2,3 DED SIG CON)               (TASK  91)
''   MPS PROP PRESSURES (MPS)                              F*(TASKS  70, 110)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  22   0      70001     381  16  2 0      16  0 0       0       3
 5  23   0      50022   70001 363  0 0     360  0 0       0       3  0  2
''
''READ FROM FA03,4
''   OMS PBK ULLAGE PRESSURES (OA3 DED SIG CON)             F*(TASK 110)
''   OMS POD PROPELLANT AVAILABLE (OMS)                     F*(TASK 101)
''   MPS FUEL VALVE STATUS (MPS, MPS ENG3)                  D (TASK 114)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  24   0      70001     358  16  6 0      16  0 0       0       2
 5  25   0      50024   70001 365  0 0     360  0 0       0       2  0  2
''
''READ FROM FA01,2
''   OMS POD ULLAGE PRESSURES (OMS)                         F*(TASK 110)
''   OMS PBK HELIUM PRESSURES (OA1/2 DED SIG CON)           F*(TASK 110)
''   OMS PROPELLANT CROSSFEED VALVE STATUS (OMS)            D*(TASK 101)
''   OMS ENG REGULATOR OUT PRESSURE (OMS)                   F*(TASK 110)
''   MPS FUEL VALVE STATUS (MPS, MPS ENG1/2)                D (TASK 114)
''   MPS PROP ENGINE MANIFOLD PRESS (LOX/LH2 ENG MANF)      F*(TASK 110)
''   RCS PROP TANK PRESS (LH/RH OMS 001, DSC OL/OR 2)F*(TASKS 102,110)
''   RCS PROP TANK TEMPS (DSC OL/OR 2, LH/RH OMS 001)       F*(TASK 102)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  26   0      70001     381 379  0 0      16  0 0       0       2
 5  27   0      50026   70001 370  0 0     360  0 0       0       2  0  2
''
''ICC FOR REDUNDANT SET (GPC 2,3, & 4 COMMUNICATION WITH GPC 1)
''(TASK 307)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  28   1        383   70001  16 256 0     16  0 0       0       3
 5  29   1      70001     384  16 256 0     360  0 0       0       3
```

```
''READ MAIN ENGINE STATUS (SSME) FROM EIU1,2,3   (TASK 181)
''*** ASSUME ALL STATUS DATA WORDS ARE READ ON EVERY CYCLE OF TASK
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  34    0     70001    359  16  2 0     16  0 0      0      3
 5  35    0     50034  70001  16 64 0    360  0 0      0      3
''
''READ FROM FF01,2,3,4   (TASKS 91, 171, 180)
''   RCS VALVE STATUS (RJDF)                                   (TASK  91)
''   RCS PROPELLANT TEMPS (DSC OF4, OF2 DED SIG CON)           (TASK  91)
''   SWITCHES AND PANEL SWITCHES                            D (TASK 180)
''   ROTATIONAL HAND CONTROLLER 1&2 (LH/RH RHC)             F*(TASK 171)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  38    0     70001    380  16  2 0     16  0 0      0      4
 5  39    0     50038  70001 387  0 0    360  0 0      0      4  0  2
''
''READ MCA STATUS FROM FA01,2,3,4
''   OMS TVC (OMS)                                    F*(TASK 65)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  40    0     70001    381  16  2 0     16  0 0      0      4
 5  41    0     50040  70001 392  0 0     16  0 0      0      4
''
''READ PROPULSION SYSTEM STATUS FROM FA02,4
''   MPS FUEL VALVE STATUS (MPS, LOX FEED DISC V)           D (TASK 116)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  42    0     70001    393  16  2 0     16  0 0      0      2
 5  43    0     50042  70001 427  2 0    360  0 0      0      2
''
''READ SOLID ROCKET MOTOR STATUS FROM LL1, LL2, LR1, LR2   (TASK 203)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  44    0     70001    354  16  2 0     16  0 0      0      4
 5  45    0     50044  70001 395  0 0    360  0 0      0      4
''
''READ FROM FA01,2,3,4
''   BODY FLAP POSITIONS (POS XDCR)                         F*(TASK  49)
''   ELEVON PRESSURE (LVON SW VLV)                          F (TASK 193)
''   RCS AFT THRUSTER STATUS (RJOD)                 D (TASKS  91, 101)
''   AFT TVC VALVE STATUS (ATVCD)                D*(TASKS 119, 120, 110)
''   OMS PROPELLANT VALVE STATUS (OMS)                      D (TASK 183)
''   OMS ENG PNEUMATIC SUPPLY PRESS (OMS)                   F*(TASK 110)
''   OMS POD HELIUM PRESS (OMS)                             F*(TASK 110)
''   ET LH2 LOW (ET)                                        D*(TASK 165)
''   MPS LOX LOW (MPS)                                      D*(TASK 165)
''   MPS LH2 VALVE STATUS (MPS)                              D (TASK 110)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  46    0     70001    381  16  2 0     16  0 0      0      4
 5  47    0     50046  70001 396  0 0    360  0 0      0      4  0  2
''
''WRITE TO FF01,3
''   RCS PROPELLANT QUANTITIES (D&C PNL 003)                F (TASK 102)
''   MPS CHAMBER PRESSURES                                  F (TASK 181)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  50    0     70001    357  16  8 0     16  0 0      1      2
```

```
''WRITE IMU TO FF01,2,3   (TASK 306)
''      NATURE  SOURCE  SINK  LENGTH       INTERVAL    START  TOTAL
 5  52    0      70001    380  16  4 0      16  0 0       1      3
''
''WRITE TO FA01,2,3,4
''   ELEVON CMDS (ASA)                                          F*(TASK  50)
''   OMS PROPELLANT VALVE CMDS (OMS, OMS L/R ENG/POD)D(TASKS 182, 183)
''   MPS PROPELLANT VALVE CMDS (MPS/1/2/3, AFT LCA)          D (TASK  70)
''      NATURE  SOURCE  SINK  LENGTH       INTERVAL    START  TOTAL
 5  53    0      70001    381 397  0 0      16  0 0       1      4
''
''WRITE TO DDU1,2
''   ADI     ALTITUDE DIRECTOR                                    (TASK 168)
''      NATURE  SOURCE  SINK  LENGTH       INTERVAL    START  TOTAL
 5  54    0      70001    382  16 22 0      16  0 0       1      2
''
''WRITE TO DEU1,2,3   (TASK 335)
''      NATURE  SOURCE  SINK  LENGTH       INTERVAL    START  TOTAL
 5  55    0      70001  60001  16 1024 0    16  0 0       1      1
 5  56    0      70001  60002  16 1024 0    16  0 0       1      1
 5  57    0      70001  60003  16 1024 0    16  0 0       1      1
''
''WRITE PRIME FRAME TO PCMMU   (TASK 307)
''      NATURE  SOURCE  SINK  LENGTH       INTERVAL    START  TOTAL
 5  58    0      70001  60095  16 512 0     16  0 0       0      1
''
''READ KEYBD 1 AND WRITE NEW DISPLAY TO DEU1   (TASK 334)
''      NATURE  SOURCE  SINK  LENGTH       INTERVAL    START  TOTAL
 5  59    0      60027  70001  434  0 0     16  0 0       0      1
 5  60    0      50059  60001  433  0 0     16  1 0       0      1
''
''WRITE MAIN ENGINE COMMANDS TO EIU1,2,3   (TASK 181)
''*** ASSUME 1 CMD WD TO EACH EIU FOR EACH CYCLE OF TASK
''      NATURE  SOURCE  SINK  LENGTH       INTERVAL    START  TOTAL
 5  61    0      70001  70011  16  4 0     16  0 0       1      1
 5  62    0      70001  70012  16  4 0     16  0 0       1      1
 5  63    0      70001  70013  16  4 0     16  0 0       1      1
''
''WRITE CMDS TO FA01,2,3,4
''   MPS ACTUATOR GIMBALS (ATVCD)                               F*(TASK  60)
''   MPS FUEL VALVE CMDS (MPS 1,2,3)          D (TASKS  70, 114, 165)
''   VENT PORTS                                                 D (TASK 161)
''   RCS AFT THRUSTERS (RJOD)                                   D (TASK 190)
''   RCS AFT PROPELLANT VALVES (RJOD)                           D (TASK  91)
''   SRB ENG ACTUATOR GIMBALS (LH/RH LT/RT SRB)                 F*(TASK  62)
''   OMS ACTUATOR GIMBALS (OMS)                                 F*(TASK  64)
''      NATURE  SOURCE  SINK  LENGTH       INTERVAL    START  TOTAL
 5  64    0      70001  60013 398  0 0     16  0 0       1      1
 5  65    0      70001  60014 398  0 0     16  0 0       1      1
 5  66    0      70001  60015 398  0 0     16  0 0       1      1
 5  67    0      70001  60016 398  0 0     16  0 0       1      1
```

```
''WRITE CMDS TO MEC1,2   (TASKS 114, 115, 116, 164)
''   SRB IGNITION ARM AND FIRE                                  D*(TASK 114)
''   SRB PICS ARM AND PICS FIRE                                 D*(TASK 115)
''   ORB/ET PWR DISCONNECT, PICS ARM AND PICS FIRE               *(TASK 116)
''   SAFE AND PWR OFF                                           *(TASK 164)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  69   0     70001   424 437  0 0     16  0 0     1      2
 5  70   0     70001   424 437  0 0     16  0 0     1      2
 5  71   0     70001   424 437  0 0     16  0 0     1      2
 5  72   0     70001   424 437  0 0     16  0 0     1      2
''

''WRITE TO LA01
''   PROPELLANT ISOLATION VALVE CLOSE CMDS (AFT LCA/2)       (TASK 70)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  73   0     70001  60035  16  4 0     16  0 0     1      1
''

''WRITE CMDS TO FF01,2,3,4   (TASKS 91, 161, 190)
''   VENT PORTS                                                 D (TASK 161)
''   RCS FWD THRUSTERS (RJDF)                                   D (TASK 190)
''   RCS FWD PROPELLANT VALVES (RJDF)                           D (TASK  91)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  79   0     70001  60009 426  0 0     16  0 0     1      1
 5  80   0     70001  60010 426  0 0     16  0 0     1      1
 5  81   0     70001  60011 426  0 0     16  0 0     1      1
 5  82   0     70001  60012 426  0 0     16  0 0     1      1
''

''WRITE ET UMBILICAL CMDS TO FA02,4   (TASK 116)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  84   0     70001  60014 389  0 0     16  0 0     0      1
 5  85   0     70001  60016 389  0 0     16  0 0     0      1
```

5 2 3 3 5 Data Sets. Data sets represent files of data allocated to auxiliary storage For representation of the DDPS, two data sets were defined, as shown in the form 11 list following. Data set 1 represents the library file from which major function overlays are selected for main memory. Since simulation of the Orbital Flight Test does not include the overlay function, it is performed as part of the initializing process of the model; nevertheless, a library data set must be specified for each routine to be addressed, and the data set must be defined.

Data set 2 represents one of the mass storage files for display images. Only one is represented as only one is to be used for a given system configuration.

Both data sets are assigned to storage 1 (mass storage facility) and are defined to be serially addressed (Org = 0) The Initial Size and Maximum Size for a data set are separately specifiable to permit dynamic change in the data content of a data set, however, this feature is not required for DDPS simulation, and therefore both fields are specified as the same: 10^7 characters for the library, and 1.024×10^7 characters for the displays.

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The scripted inputs for these data sets on IMSIM Specification form 11 were as follows

```
''      STORAGE   ORG   INIT.SIZE   MAX.SIZE
''
11   1     1       0        10000       10000
11   2     1       0        10240       10240
```

5 2 3 3 6 Executive Algorithms IMSIM form 13 is used to select from among various options the methods to be used by IMSIM in performing some of the functions normally relegated to executive or operating systems of computers. While some are not relevant to DDPS simulation, they are all specified and listed below with clarification as needed.

```
''**** ALGORITHM SELECTION ***************************************
''
''     1A  1B  2A  2B  2C  2D  2E  3A  3B  3C  4A  4B  5A  5B  6A
13      1   0   1   1   0   0   0   1   1   1   1   1   0   0   0
```

1A If alternative paths between a source and sink are available, but all are in use when a transmission is to be performed, defer the transmission until any path becomes available.

1B If more than one path for a transmission is open, choose the first one in the list

2A, 2B, 2C, 2D, 2E These options pertain to memory allocation and are not meaningful for the DDPS simulation.

3A, 3B Processing is interruptible for executive functions and for tasks of service class 1

4A This option pertains to use of nonshareable systems components (other than a CPU) by tasks, and is not relevant to DDPS simulation.

4B All transmissions are to be over explicitly defined data links; i.e., no implicit links are allowed

5A, 5B These options pertain to simulation of program loading and are not relevant to the DDPS simulation.

6A The CPU is not to be interrupted in performing a task in order to initiate and service I/O (this function is performed by the IOP of the DDPS)

5.2 4 Model Execution (SOW 3 4)

This section describes the work performed under Task 3 4 as defined in the Statement of Work (Exhibit "A") of contract NAS 9-15010.

5 2 4 1 Summary of Run Types. There were several generic types of runs made, each of which were tailored to a specific form of analysis The types of runs included

a Concentrated (condensed) Runs - Initial testing areas

b Transition Runs - To test transitions between Major Modes

c No Message Runs - Data Messages were deleted to simplify analysis of CPU utilization

d Long Duration Runs - To determine long-term effect of CPU overload

e High-Speed Runs - Runs with processor speed and memory access rates quadrupled from actual rates to determine processor overload.

Descriptions of each of the run types are given below The initial set of runs largely consisted of Concentrated runs and Transition runs The "No Message" runs and the Long Duration runs were made to further analyze the high CPU utilization observed in the initial runs

5 2 4 1 1 Concentrated Runs. The cyclic nature of the Shuttle's software functions generally results in a fairly uniform loading following an event, with major changes occurring only in response to the events themselves Thus, each event will have an associated loading pattern which can be determined within a fraction of a second after all of the activities associated with an event have been initiated Once this loading pattern has been determined, no additional information will be available until the next event (or system state change). To simplify the analysis, the sequence of events in the job schedule is compressed in comparison to the real-time sequence of events The simulated events for the Shuttle Ascent phase are schedule depending on the Major Mode

In MM101 (Terminal Count) the events were introduced externally through the job schedule at intervals based on the actual countdown The countdown real time was scaled down by a ratio of 10 1 for simulated countdown time (see table 5-9)

The events in the other Major Modes were generated as discussed in section 5 1 4 4 at intervals of 275 ms and some at 175 ms and 50 ms.

5.2.4.1 2 Transition Runs. A number of simulation runs were made for the purposes of observing the transition between one Major Mode and the next These runs are significant because some of software functions must be terminated at the transition, and new functions are initiated These runs were intended to demonstrated whether or not the transition made in an orderly manner and to identify any bottlenecks at the transition. The IMSIM checkpoints established at the end of these runs also permitted runs to be started without having to rerun previously simulated Major Modes

5 2 4 1 3 No Message Runs The initial runs employed a faithful representation of the message traffic during short segments of simulated flight In particular, the message traffic during a segment of each Major Mode was examined as well as the message traffic during Major Mode Transitions These runs were examined in detail for any potential loading problems or significant delays in task execution that might result from failure to acquire essential data buses or devices These runs established that the message traffic did not result in any significant delays or degradation However the runs did indicate a high CPU utilization Because the message traffic had a minimal effect on task execution, a number of simulation runs were made with the message traffic deleted These runs were made for the specific purpose of more fully studying the effects of the high CPU utilization observed in the initial runs.

5 2 4 1 4 Long Duration Runs A number of long duration runs were made to determine the effect of the total computation time of some of the lower priority long cyclic Principal Functions These functions are continually interrupted by the higher priority functions and the time duration therefore had to be stretched for proper analysis

5 2 4 1 5 High Speed Runs A majority of the runs showed a processor utilization close to or at 100 percent In these runs, a number of lower priority functions were unable to run to completion within the cycle time for the function To quantitatively assess the CPU overload, short segments of these runs were made with the processor speed and memory access rate increased by a factor of 4. The increased processing speed allowed the majority of tasks to complete The total processor utilization for the run segment was then multiplied by 4 and divided by the run duration to determine the amount of CPU overloading.

5.2 4.2 Initial Set of Simulation Runs. The first set of runs was to validate the model and to give an overview of system performance After the validation runs that exercised the simulated hardware and software, two timelines, hereafter called "jobschedules", were developed that encompassed the major modes of flight The first, JSCF1 shown in table 5-9, was used to simulate MM101, the second jobschedule, JSCF4 shown in table 5-10, was developed for Major

Modes 102, 103, and 104 as well as all Major Mode transitions The first column in the tables indicates the time (in milliseconds) at which the job or event is introduced to the system The second column specifies the job to be initiated A zero in this column indicates that the next four fields are events to be set in Savex cells (column 3 = Savex cell number, column 4 = value to be set in this Savex, column 5 = 2nd Savex cell number (if any), column 6 = value to be set in this 2nd Savex, if applicable)

The events in MM101 were based on the actual countdown scaled down by a factor of 10 The events in the other Major Modes were generated as described in section 5.1 4.4

Table 5-9. Jobschedule JSCF1

```
''JOBSCHEDULE - NASA JSCF1 DATA          06 DEC 1976
  20      2                        ''START JOB 2
  30      3                        ''START JOB 3
  40      4                        ''START JOB 4
  50      5                        ''START JOB 5
 200      0     643       1        ''FORCE OVERRIDE SRB          EVT7
 400      0     643       2        ''SRB FCS/HYD  VERIF         EVT8
 600      0     643       4        ''SRB/FCS/HYD. VERIF COMPL    EVT8A
 750      0     643       8        ''PLATFORM UPDATE             EVT11
 900      0     643      16        ''VENT DOORS CLOSE CMD        EVT13
1050      0     643      32        ''VENT DOORS CLOSED ——        EVT13
1200      0     643      64        ''NAV INITIATION              EVT14
1450      0     643     128        ''GO SSME START               EVT15
1550      0     643     256        ''FORCE OVERRIDE MPS          EVT16
1700      0     643     512        ''SSME START                  EVT17
2000      0     643    1024        ''SRB IGNITION                EVT19
2000      0     644       1        ''SRB IGN. MM102 START        EVT19
N
```

Table 5-10. Jobschedule JSCF4

```
''JOBSCHEDULE - NASA. JSCF4  DATA
  20    2          ''START JOB 2
  30    3          ''START JOB 3
  40    4          ''START JOB 4
  50    5          ''START JOB 5
  N
```

The sequence of events for MM101 is controlled through the jobschedule JSCF1 shown in table 5-9. Savex call X643 is used to indicate the event number within the major mode The cell X643 is set to powers of 2 to define the event within the major mode. Thus a value of 1 (i e., 2^0) is used to indicate

event 7 (Redundant Set Auto Sequence Start) in MM101. A value of 2 (i e , 2^1) is used to indicate event 7 (Force Override of SRB Actuators) The correspondence between the power of 2 values of X643 and the events in MM101 are shown in section 5 2.1.1 (Savex cells System Conditions and Settings) The successive powers are used to indicate only those events that are ordinarily executed Events such as event 9 (Hold count) and event 10 (Resume count) are not necessarily executed and, if executed, these events need not occur in the normal numerical sequence defined by the event numbers. As a consequence these special events are initiated through the Savex cell X675

Savex cell X643 is initially set to 1 which corresponds to event 6 in MM101 At 150 ms, the Savex is incremented by 1 (i e , X643 = 2) to indicate event 7 (Force Override of SRB Actuators). At 400 ms the jobschedule specifies that X643 will be incremented by 2 (i.e, X643 = 4) to indicate the start of event 8. Thus each event within MM101 is introduced as an exogenous event with the sequence of events controlled by incrementing Savex cells X643 by powers of 2 through the jobschedule.

The initial conditions for the condensed run made for MM101 are given in section 5 2 1.2 A single jobscheudle is used for Major Modes 102, 103, and 104 as well as those runs simulating the transitions between the Major Modes. The actual sequencing of events is performed by IMSIM and is controlled through the initial conditions. For these runs, the simplified jobschedule, JSCF4, shown in table 5-10 was used This jobschedule merely introduces the group 2, 3, 4, and 5 tasks into the system Jobs 2, 3, 4, and 5 are introduced to the system through the jobschedule at 20 ms, 30 ms, 40 ms, and 50 ms respectively. The actual execution of the jobs is initiated at the simulated time specified by Savex cell X640. By setting the values of this Savex cell in the initial conditions, the execution of each group of tasks can be initiated at any desired time or event

The sequence of events within Major Modes 102, 103, and 104 or the transitions between Major Modes is controlled through the Savex cell X3278 This Savex cell specifies the time interval between events within the Major Mode An event mask for Major Modes 102, 103, and 104 is maintained in the respective Savex cells X644, X645, and X646.

The initial conditions for the transition run from MM101 to MM102 are listed in section 5 2 1 2. These initial conditions were input from the NASA REVAR54. DATE file after the initial conditions for MM101 were read in These runs were started at event 17 (SSME Start) by setting the event mask Savex X643 to 1024. In the initial conditions, the simulation start time was 100 ms as specified through the Savex X643, and the transition to MM102 occurred at 2000 ms as defined using Savex X3277 The interval between events is specified in Savex cell X3278 to be 50 ms Hence the event mask was incremented by IMSIM every 50 ms. In other runs this increment was increased to 275 ms.

The initial conditions for the transition from MM102 to MM103 are given in section 5 2 1 2. These initial conditions were input from the NASA.REVAR54 DATA file after the initial conditions for MM101 and the transition run from MM101 to MM102 had been read in.

5.2.4 3 Testing Variations. Within the Major Modes listed above, there are several events that represent abnormal conditions and that would not ordinarily be covered in the initial set of runs The fact that these events relate to the crew and vehicle safety merits their inclusion as special areas of investigation. Inclusion of these events is considered important because they generally represent an additional loading of the system. The areas for investigation include

a Major Mode 101 - Hold Count (event 9)

b Major Mode 101 - Resume Count (event 10)

c. Vehicle Safing (event 23)

d OMS Failure (event 40A or 40B)

The Pad Shutdown (event 20) is not included since this activity precludes a launch and is therefore considered to be of secondary importance with regard to this study The abort moding control sequence is outside the scope of this study and therefore was not simulated

Because the events listed above would not ordinarily be executed, they are initiated as exogenous events through the appropriate jobschedule Savex cell X765 is used to initiate events 9 (Hold count) and 10 (Resume count) while X687 is used to initiate event 23 (Vehicle Safing), and X685 is used to initiate event 40A or 40B (Left or Right OMS Engine Failure)

The Vehicle Safing activity can be executed anytime between SRB Ignition and MECO This encompasses portions or all of Major Modes 102 and 103 For the purpose of producing a worst-case situation, the Vehicle Safing event is scheduled during a high-load activity period

The OMS Failure can only occur after the MECO command (event 32). Hence this event is scheduled during the latter portion of MM103 or during MM104. It is assumed that the left and the right engines failures are mutually exclusive.

However, due to the execution problems of the Principal Functions as described in sections 2 and 3, Results and Conclusions, the simulation of these exogenous events served no purpose as the normal execution of functions did not even complete.

The jobschedules and initial conditions for the "No Message" runs are identical to those used for the runs made with messages The "No Message" runs were made using the NASA.T5NMO.DATA file instead of the NASA SPECS50.DATA file

The NASA T5NMO DATA file is identical to the NASA SPECS50 DATA file except that all message references have been deleted from the form 3 (Task definition) and form 5 (Message definition) specifications.

The initial conditions for the High-Speed runs (in addition to the initial conditions used to specify the Major Mode) were as follows:

```
S   X111 = 1 92  - increases processor speed by a factor of 4.
S   X441 = 5.6   - increased memory access time by a factor of 4.
```

5 2.5 Test Analysis and Documentation (SOW 3 5)

The following paragraphs describe in detail the procedures and work performed under this task. They included preparation of a Test Plan (reference 5) which was submitted to NASA on 5 November 1976, and which culminated in this Final Report.

5 2 5 1 Simulation Results. The simulation runs executed as described in section 5.1 4 produced an abundance of results by means of history printouts, statistical reports, and table tallies.

A short description of these types of reports follows.

a. Statistical Reports.
For a quick analysis, 10 statistical reports were printed out at the end of each simulation run.

1 Job and Task Reports
Reports numbered 2 and 4 give statistical data on the total number of jobs, tasks, and messages that are initiated, completed, interrupted, delayed, in progress, number of activations, number of task abortions, etc.

2 Utilization Reports.
Reports 13 through 18 provide statistical data on usage of processors, memories storages, devices, data links, and data sets. These reports give total time usage, maximum and average times, and associated rates.

Each prototype report is repeated for as many units as are specified on the input forms, e.g , one copy of report 13 for each device used during a simulation run

3 Backlog Reports.
Reports 20 and 21 provide the transaction backlog with maximum, average and current figures plus the average delay time in ms for the key blocks in the model

All these reports are embodied in the IMSIM model version 04B and described in reference 3, except report #2 which was modified to appear as follows

```
REPORT 2 1 1
 DURING V442†   SECONDS OF SIMULATED SHUTTLE OPERATIONS
 A TOTAL OF BW1160 DIFFERENT FUNCTIONS WERE INTRODUCED
 THESE FUNCTIONS WERE ACTIVATED BW1166 TIMES. STATUS IS:
       BW1196 WERE COMPLETED
        B1167 ARE WAITING FOR NEXT ACTIVATION
        B3032 ARE IN READY STATE, I.E. WAITING FOR CPU
        B1182 ARE WAITING FOR MESSAGES TO COMPLETE
         V443 PRESENTLY EXECUTING, I E. IN ACTIVE STATE
 FUNCTIONS WERE INTERRUPTED BW2000 TIMES.
  X659 FUNCTION ACTIVATIONS WERE ABORTED AS FUNCTION STILL ACTIVE. ENDR
```

†This format representation includes applicable MODLIT entities (e.g., V442) which are evaluated by MODLIT and inserted into the report whenever report 2 is output.

b. Data Flow Reports.
These reports present the activities that take place in the model during a simulation run. They are also considered to be history printouts.

1 Message Reports.
Reports 5 and 6 give all the particulars for each of the data flow messages, such as message length, origin (source), and destination (sink) of the data message, time of occurrence, transmission rate, data bus number, etc. These reports are embodied in the IMSIM model version 04B and defined in reference 3.

2 Job Reports
Reports 8 and 9 indicate at what time a job started and finished and total time consumed for job execution. These reports are embodied in the IMSIM model version 04B and defined in reference 3.

3 Task Reports.
Reports 25 through 31 give all details of task transactions during a run such as start and finish of a task, execution time, message wait, task interruption, computation time, time of abort, etc.

These reports are incorporated in the IMSIM model version 04B except reports 30 and 31, which are printed below

```
REPORT 30 1  1 X577†
                        *** ABORTED ***    ENDR
REPORT 31 1  1 G43†
      C1 TUS     TG     GO FOR     TASK        P4 ENDR
```

4 Event Related Reports
Reports 35, 37, and 40 give details on time and transition to a new Major Mode, time and indication of an OMS engine failure and when it occurred in MET, and time and occurrence of a normal numbered event in a Major Mode

Reports 36 and 38 give details on the countdown, time, count, and hold count These reports were all added to the IMSIM model version 04B and are given below

```
REPORT 35 1 1
 **AT TIME     C1 TRANSITION TO MAJOR MODE X663 OCCURRED. ENDR

REPORT 36 1 1 X3258
 **AT TIME     C1 COUNTDOWN STOPPED DUE TO HOLD COUNT COMMAND,
   COUNTDOWN CLOCK IS STOPPED AT - X661 SECONDS. ENDR

REPORT 37 1 1 X3259
 **AT TIME     C1 FROM START, OMS ENGINE FAILURE OCCURRED AT
   MISSION ELAPSED TIME (MET)   V417 . ENDR
```

†This format representation includes applicable MODLIT entities (e.g , X577) which are evaluated by MODLIT and inserted into the report whenever report 30 is output.

```
REPORT 38 1 1 X3258
 **AT TIME     C1 COUNTDOWN CLOCK IS AT - X661 SECONDS AND COUNTING.
   ENDR

REPORT 40 1 1 X3258
 **AT TIME     C1 , EVENT X3280 IN MAJOR MODE X663 OCCURRED. ENDR
```

c. Control Reports.
These reports were provided to detect situations in which capacities are exceeded or unusual activities take place. Report 12 gives a printout of errors occurring during a simulation run. Report 42 was used as a control tool to evaluate the various system capacities during a simulation run. All control reports were embodied in the IMSIM model version 04B and described in reference 3.

d Table Tallies
A tally operation was included in the model to count the number of times each task was activated during a simulation run. Table 1 was defined to keep the scores for each task on the basis of its index. The scores do not include reactivation of a task following interruption. The first two columns of the table 1 printout show the task indices, to relate an index to a task, it is necessary to find reference to the task index in a START statement of the history printout and read the corresponding task number. The next (third) column shows the activation score for each task Since there is no useful relation between the individual scores, the remaining columns contain extraneous information (however, the last entry in the CUM SCORE column shows the total number of task activations)

The report numbering is not sequential as numbered reports were changed, added, or deleted during previous versions of IMSIM.

Representative printouts of these reports followed the simulation runs as defined in section 5.2.5 2, and are given in appendix D for the Statistical Reports and Control Reports, and in appendix C for the Data Flow Reports that occurred during these simulation runs.

The results of the analysis of these runs and reports are given in section 2, Results, and in section 3, Conclusions, of this Final Report.

Some runs were plotted for easier analysis of delays, functional interruptions and aborts See section 2, Results, for these graphs

Lower priority tasks experienced delays in their execution from 1 ms up to 58 ms and were aborted on the occasions where a new activation was to be executed and the current execution was not completed at that time

5 2.5.2 Backlogs and Delays. Many of the problems of congestion and contention for resources which are present in most data processing systems are automatically measured and reported during simulation runs using IMSIM. The DDPS design eliminates the possibility of a number of these problems. Furthermore,

some of the measurements gathered by IMSIM relate directly to input specifications and parameters, and therefore provide no insight into the dynamic system behavior. Data which are meaningful in the context of DDPS simulation are extracted from the general simulation results and presented in section 2 The following discussion pertains to the general results, as printed in reports 20 and 21, and may prove useful in indicating problems which the DDPS design has avoided or minimized.

Scheduled processes are essentially independent of each other (i.e., they are not organized in predecessor-successor relationships), so that backlogs of dependent tasks--measured in IMSIM block 1138--do not develop.

Memory is allocated and programs and data loaded as required for major functions of the OFT, prior to T-19 seconds. Thus, the nominal allocation activity--measured in IMSIM block 1151--is not relevant to the DDPS model. For the same reason, the following measurements are not meaningful

a The backlog of program elements which cannot be allocated due to lack of space in virtual memory - block 1488.

b Program elements currently in loading - block 1495.

c. Executive (FCOS) service for loading of program elements - block 1935

d Time spent in consolidating virtual memory space - block 1936.

e. The backlog of elements waiting for space in specific memory units - block 6002.

f The backlog of elements waiting for space in any memory units - block 10052

The time used by FCOS in activating processes is integrated with the scheduled processes, and job/task initiation service--measured by block 1204--is bypassed.

The number of scheduled processes in the DDPS does not vary with time. Thus, block 1201, which measures the number of schedulable tasks, simply records the number of scheduled processes introduced to the model

Statistics relating to processes in actual execution (i.e., having a CPU assigned) are recorded in block 1184 Times recorded in this block are fragmented by task interruptions and thus indicate only the time periods continuously devoted to individual tasks Data for this block, from various simulation runs, are shown in appendix D.

Tasks which enter a "wait" state for completion of I/O are recorded in IMSIM block 1182. These data are presented for various simulation runs in appendix D.

The DDPS is not configured as a multiprocessor (i.e., two or more CPUs cannot address the same main memory unit). IMSIM block 1185 records interference between processors in addressing the same memory; it has no useful information for the DDPS simulation.

The queue of processes that are ready for dispatching, either as the result of scheduling or as a consequence of interruption by higher priority processes, is represented by the backlog of tasks recorded in IMSIM block 3032. Data pertaining to this backlog for various simulation runs are shown in appendix D

So-called cyclic scheduling of IMSIM is not the same as the scheduling of cyclic processes within the DDPS. Rather, it refers to a "round robin" scheduling algorithm; since the latter is not simulated, the data pertaining to task queues for this type of scheduling--recorded in blocks 3004 and 3005--are absent in summary printouts of DDPS simulation runs.

Task switchover time (i.e., the time it takes FCOS to store the status of an interrupted process and establish status for the interrupting task) is assumed to be well below the 1 ms threshold of time resolution, and statistics on switchover time--recorded in IMSIM block 3089--are not significant.

As defined for IMSIM, "sink-driven" messages represent transmissions which are initiated in conjunction with task execution. If they are to be deferred until some time after the start of a task, a "start" specification is included in the message definition (IMSIM form 5). IMSIM block 1605 records statistics on message delays due to the start conditions. If a sequence of transmissions is defined as a sink-driven message, IMSIM block 1846 records statistics on the time between successive transmissions of the message.

All DDPS processes are described as repeatable or "cyclic" tasks to IMSIM. Since block 1601 records data for noncyclic tasks, it has no function in the DDPS model.

Only ICC messages were characterized as "source-driven" for the DDPS model; this was done to achieve concurrent transmissions Start times for these messages are specified as 0. Thus, statistics on source-driven message delays for transmission starts--recorded in blocks 1608 and 1851--are irrelevant to the DDPS model. Response time is specified as an input parameter via IMSIM form 5, statistics on response transmission response periods are recorded in block 1675.

Since the DDPS software is designed as a single, integrated unit, there is no need to employ the concept of "nonshareable" resources (i e , resources such as bus terminals which must be reserved for use by a single task). Thus, backlog statistics on tasks which must acquire nonshareable resources--recorded in IMSIM blocks 1682 and 1866--are not relevant.

Mass memory is not employed in the OFT simulation, and since no other components of the DDPS are represented as auxiliary storage devices for data transmission, statistics relating to the use of such components--recorded in blocks 1706, 1707, and 1748--are not relevant

No statistics are recorded on I/O initiation and completion interrupt service, since these functions are incorporated in the software representation and are assumed to require negligible processor time (considering the 1 ms time resolution of the DDPS model), thus data on periods during which these functions are performed--recorded in blocks 1693 and 1808--are absent.

Statistics were recorded on the backlogs which develop when message transmissions are deferred due to current use of a data bus or bus terminal required for the transmission. These data are recorded in blocks 1708, 1712, 1738, and 8005.

Since multiplexed transmission links are not employed in the DDPS model, statistics on acquisition of such links--recorded by block 1734--are absent.

Statistics were gathered on transmission backlogs which develop as the result of I/O saturation of memory (i.e., a condition in which a sufficient portion of the memory access cycles are being utilized during a period to preclude additional, fixed-rate transmission) These data are recorded in blocks 1751 and 1753

The IMSIM block 1754 records data concerning the transmission periods of all messages which are sent during a simulation run.

Reset periods for bus terminals were defined as zero, to represent negligible time periods. Thus, data gathered on device reset periods in IMSIM block 9052 are not meaningful.

5 2.5.3 Overall Workload Behavior. Assessments regarding the acceptability of each run were gained from inspection of several postrun narrative reports that depict overall configuration behavior. Particular emphasis was placed on throughput of simulated software components (jobs, tasks, and messages). The information contained in these reports that is pertinent to the DDPS is described in section 5.2.5.1.

Of particular interest to DDPS applications were the task completion statistics, which indicated the degree to which workload elements were satisfactorily concluded, and the message transmission statistics, which provided information as to the satisfactory behavior of data bus traffic and of traffic on the channels and data links connecting MDMs and PCMMUs to these buses.

5 2.5 4 Hardware Component Utilization. Following the initial inspection of workload summary statistics, attention was directed towards utilization statistics that detail the behavior of individual hardware components Specific component utilization reports that have meaning for the DDPS configuration are the Processor utilization reports, the Data link utilization reports, and the Device utilization reports These reports are detailed and described in section 5.2.5.1.

The processor utilization data were of interest in assessing the degree to which the GPC computers are used in each run, and indicate the degree to which the units are saturated during these tests. Utilization figures on data links and devices were inspected to note abnormally low or high use of these components, with special attention being directed towards PCMMU devices, their associated data links and buses, and key MDM devices. Inordinately low usage of these components could indicate the need for reallocation or reconfiguration of such units for more efficient utilization, while high usage statistics could imply the need for additional components or a restructuring of the workload to alleviate saturation conditions and potential bottlenecks.

5 2 5 5 Software Component Utilization Based on inspection of the overall workload summaries and hardware component statistics, attention was directed towards the behavior of specific tasks and messages. The following kinds of information were gathered for specified components

a Task behavior for each given task type (e g., user interface, ascent digital autopilot), tabulations were made of maximum time required for completion per run, number of times invoked, and number of times interrupted,

b Message behavior for each given message type (e g , write commands to EIU, reading of RCS propellant temperatures), tabulations were made of maximum time for transmission per run, number of times initiated, and number of times interrupted

These data were augmented by specialized reports to further depict the characteristics of software components that were executed several times in the course of a test and to determine the timeline dynamics of tasks and messages of significant interest Means, standard deviations, cumulative scores, and other data were used to assess relative behaviors of these entities Software components that are associated with SSIP and FC processing received special attention.

5.2 5 6 Transaction Analysis. The generalized workload summaries and component-specific tabulations described in sections 4.1 through 4 3 permit efficient analysis of the behavior of simulated portions of the system as parametrically input to IMSIM In addition to these model-related statistics, several post-run transaction-oriented reports generated by IMSIM's host interpreter "MODLIT" were employed to augment these IMSIM component statistics This was accomplished by generating data relating to generalized MODLIT components The reports were used to isolate inordinate backlogs and bottlenecks that occur in these runs, with emphasis on the flow of MODLIT traffic elements (transactions) through static MODLIT system entities (blocks) Data that were so utilized are as follows

a. Key block summary an abbreviated summary of the behavior of key blocks in the model provides, for each block, the transaction backlog (maximum, average, and current) and the average transaction delay (for all transactions and for delayed transactions only),

b Detailed block printout· a full summary of the behavior of every block in the model provides, for each block, the number of transactions through the block, the transaction backlog (maximum, average, and current) and the average transaction delay (for all transactions and for delayed transactions only);

c Activity summary· a tabulation of the detailed model traffic that is totaled according to specific types of MODLIT operations produces information on transaction associated data This report is described in detail in Reference 3 and in section 5.1.4.5 4

d Task scheduling queues. a summary of task backlogs for the run, including total number invoked (delayed and undelayed), queue length (maximum, current, and average), and average wait (all units and delayed units only);

e Detailed transaction summaries tabulations of data that specify the status of one or more selected transactions, including associated transaction parameters (up to five), current transaction priority, and associated pushdown stack entries for each transaction,

f Facility reports· MODLIT summaries of processor, data link, and device behavior that supplement those produced by IMSIM, including utilization statistics, current priority, current recourse (MODLIT block to which the current user is routed if evicted), and number of transactions evicted without recourse

These reports were employed to provide more detailed analysis of model behavior so as to determine specific causes for system problems that were uncovered in the more general analyses of the IMSIM reports

5 2 5.7 Detailed Real-Time Workload Flow Based on the preceding analyses, individual jobs, tasks, and messages were traced as they progressed in simulated real time through the network. For this purpose, the following reports were provided, and were generated immediately as each respective event occurred.

a. Job progress reports start time, completion time, and elapsed time for each job,

b Task progress reports start time, scheduled time, interrupt time, execution time, and completion time for each task;

c. Message progress reports start and end times (including associated task and job).

These reports permit the tracing of the characteristics of specific software components in simulated time. This is especially helpful for suspected jobs, tasks, or messages that appear to be causing inordinate backlogs, delays, or resource utilization on the configuration.

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5 2 5.8 Documentation The documentation part of this task resulted in the following publications

a. Six monthly Progress Reports, TM-(L)-5727/001/00 through TM-(L)-5727/006/00, issued on the 20th day of each calendar month during the contract period (DRL Item No 1)

b A Test Plan for the DDPS Timing Sensitivity Analysis, TM-(L)-5328/841/00, dated 5 November 1976 (DRL Item No. 4).

c A Final Report on the DDPS Timing Sensitivity Analysis, TM-(L)-5813/000/00, dated 18 February 1977 (DRL Item No 2).

d No related written or oral presentations at professional meetings or in professional journals were made in the course of this contract. Thus, no publications were made by SDC in conjunction with DRL Item No. 3, "Review of Technical Information Releases"

APPENDIX A

NASA.REVAR54.DATA

This appendix provides the following:

a The matrix values of the NASA-unique variables, discussed in sections 5 2.1 4, 5 2.1 5, 5 2.1.8, and 5 2 1.9.

b The revisions to IMSIM version 04B, described in sections 5 2.1 3, 5 2 1 6, and 5.2 1.7.

c NASA-unique reports incorporated in the model as described in section 5 2 5 1

d Logic changes for IMSIM version 04B to facilitate the OFT simulation as incorporated according to section 5.2.1 10.

e Initial conditions to be used with start of simulation runs and described in section 5 2 1 2

```
''    NASA.REVAR54.DATA  -  01/18/77
''
''NASA COMMENTS ON TEST PLAN INCORPORATED 6 DEC.76
''
''REVISIONS ARE VALID ONLY FOR IMSIM VERSION 04B
''
''DELETE DISTRIB VARIABLES FROM IMSIM TO ACCOMMODATE EXTERNAL VAR.
V143 = 0
V220 = 0

''  A. ****************** NASA UNIQUE VARIABLES ********************

      ''COMP TIME FOR ROUTINE 13
V325  = DFN (G(V299))(
      2 74       0
      0.025      1)

      ''COMP TIME FOR ROUTINE 14
V326 = DFN (X644)(
      0.015       0
      0.082       1
      0.01      128
      0.039     512)

    ''COMP TIME FOR ROUTINE 170
V327 = DFN (X663)(
      0.072      100
      0.485      500)

      ''COMP TIME FOR ROUTINE 171
V328 = DFN (X(V107))(
      1.64       6
      7.49       7
      6.53       8)

    ''COMP TIME FOR ROUTINE 183
V329 = DFN (G(V299) X663)(
      0.11     0      101
      0.135    0      102
      0.188    0      103
      0.072    1      101
      0.096    1      102
      0.15     1      103)

      ''COMP TIME FOR ROUTINE 202
V330 = DFN (V366  X663)(
     3.07      0      101
     3.648     0      102
     2.264     0      103
     3.3       1      101
```

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

```
      3.875     1     102
      2.264     1     103)

       ''COMP TIME FOR ROUTINE 203
V331 = DFN (X663  X672)(
       0     101      1
      4.056  102      1
      3.903  102     12
      1.877  103      1
      1.8    103     12
      1.368  104      1)

       ''COMP TIME FOR ROUTINE 204
V332 = DFN (X687  X663)(
      0.072     0      0
      2.338     0    102
      2.04      0    103
      1.2       0    104
      7.148     1    102
      4.656     1    103
      1.2       1    104)

       ''COMP TIME FOR ROUTINE 207
V333 = DFN (X688  X663)(
      1.013     0     101
      0.02      0     103
      0         1     101
      0.936     2     101
      0.02      2     103
      0         3     101)

       ''COMP TIME FOR ROUTINE 212
V334 = DFN (X663)(
       0.087     101
       1.01      102
       0.12      103
       0 012     104)

       ''COMP TIME FOR ROUTINE 215
V335 = (1.73 + (1 - RF1/1.2)*360 + (1 - RF2/1.4)*40.8)*0.48 + V351

       ''COMP TIME FOR ROUTINE 216
V336 = DFN (X687)(
       0.288     0
       0.77      1)

       ''COMP TIME FOR ROUTINE 163
V337 = X44 + RF1*0.025

       ''COMP TIME FOR ROUTINE 177
```

```
V338 = DFN (X(V107))(          ''MAXIMA
      0.54      70
      0.614    115
      0.460    116
      0.287    161
      0.25     164)

V339 = DFN (X(V107))(           ''MINIMA
      0.07      70
      0.32     115
      0.03     116
      0.287    161
      0.05     164)

V340 = (RF1*(V338 - V339) + V339)*0.48

      ''COMP TIME FOR ROUTINE 176
V341 = 0.3 - X661$15*0.3 + 0.1*(X643$2048 - X643$1024)

      ''COMP TIME FOR ROUTINE 185
V342 = DFN (V403  X678  X685)(
    0.006    0      0     0
    0.22     1      0     0
    0.425    2      0     1
    0.251    2      1     0
    0.443    2      1     1
    0.233    2      2     0
    0.611    2      2     1
    0.233    2      3     0
    0.425    2      3     1
    0.246    3      0     0
    0.432    3      2     0)

      ''COMP TIME FOR ROUTINE 210
V343 = DFN (X657  G(V299))(
     4.4     0      0
     0.9     0      1
     4.4     1      0
     0.9     1      1
     4.9    12      1)

      ''COMP TIME FOR ROUTINE 214
V344 = DFN (X(V107)  X690)(
     0.66     91      0
     1.04     91      1
     0.09     92      0
     0.14     92      1)

      ''COMP TIME FOR ROUTINE 218
V345 = 0.74 - X645$256*0.16 + X645$512*0.32
```

```
      ''COMP TIME FOR ROUTINE 162
V346 = DFN (X(V107))(
      0.51     60
      0.375    62
      0.183    64)

      ''PART OF V440 - COMP TIME FOR ROUTINE 206  DBCMDS-S2G
V347 = (V438$2 - V438$2*2 + V438$6*3)*RF1*3.88*0.48

      ''PART OF V440 - COMP TIME FOR ROUTINE 206· DBACCEL
V348 = (1 - V438$5)*RF1*0.843*0.48

      ''PART OF V440 - COMP TIME FOR ROUTINE 206. DBQUAT
V349 = (1.096 + V438$2 - V438$3 - V438$4 - V438$5*0.184)*0.48 + V447

        ''COMP TIME FOR ROUTINE 301
V350 = X44+(X669 - X669$2 - X669$3 + X669$4*4 - X669$5)*0.015 + V352

      ''PART OF V335 - COMP TIME FOR ROUTINE 215
V351 = (1 - RF3/0.5)*4.18*0.48

      ''PART OF V350 - COMP TIME FOR ROUTINE 301
V352 = (X669$6 - X669$7 - X669$8*8 - X669$9)*0.015

        ''COMP TIME FOR ROUTINE 309
V353 = DFN (X663)(
2.88        0
2.544     100)

        ''SINK FOR MESSAGE 44
V354 = P8 + 60029

        ''COUNTDOWN CLOCK COUNTER
V355 = X3256$1000

        ''COMP TIME FOR ROUTINE 45
V356 = 1.09 + (RF1) * 0.2

        ''SINKS FOR FF01,3 (MSG 12 & 50)
V357 = 60009 + P8$2*2

        ''SINKS FOR FA03,4 (MSG 24)
V358 = P8 + 60014

        ''SINKS FOR READ ME FROM E1U (MSG 34)
V359 = P8 + 70010

        ''INTERVAL FOR RESPONSE FROM MIA'S
V360 = 0
```

```
        ''LENGTH FOR MESSAGE 7
V361 = DFN (X(V107))(
     4       42
     2       91)

        ''COMP TIME FOR ROUTINE 303
V362 = (0.56 + RF1 * 0.03) * 0.48

        ''LENGTH FOR MESSAGE 23
V363 = DFN (X(V107))(
     8       40
     4       52
    14       70
     2       91
    14      110
     8      115)

      ''STARTING EVENT OCCURRENCE DETERMINATION
V364 = X(P8) - P9

        ''LENGTH FOR MESSAGE 25
V365 = DFN (X(V107))(
    26      101
     4      110
     2      114)

        ''DETERMINE 80 MS TIMESLICE
V366 = X660'2

        ''PLATFORM RELEASE
V367 = X673'2

        ''COMP TIME FOR ROUTINE 306
V368 = (X44 + V369) * 0.48

V369 = DFN (X663)(
     0.3      0
     0.54   100
     0.16   305)

        ''LENGTH FOR MESSAGE 27
V370 = DFN (X(V107))(
     30       101
     56       102
    122       110
      2       114)

        ''SET TIME FOR SAVEX 660
V371 = V375 + V376
```

```
V372 = C1'80

V373 = C1'320

V374 = C1'2000

V375 = DFN (V372, V373)(
    111       0      0
    001       0     40
    011       0    160
    001       0    200
    000      40      0)

V376 = DFN (V374)(
   11000      0
       0     40
    1000   1000
       0   1040)

        ''SET TIME SLICE COUNTER X657
V377 = X657'12 + 1

        ''CONDITION FOR GMA OPERATION
V378 = DFN (X663, V367)(
     1        0     0
     0       01     0
     1      101     1)

        ''LENGTH FOR MESSAGE 26
V379 = DFN (X(V107))(
     2       101
     4       110
     2       114)

        ''SINKS FOR FF MESSAGES
V380 = P8 + 60008

        ''SINKS FOR FA MESSAGES
V381 = P8 + 60012

        ''SINKS FOR DDU MESSAGES
V382 = P8 + 60016

        ''SOURCES FOR ICC MESSAGES
V383 = P7 + 70001

        ''SINKS FOR ICC MESSAGES
V384 = P8 + 70001
```

```
       ''NEW DISPLAY DETERMINATION
V385 = DFN (X669)(
       0      0
       2      3
       0      4
       2     15
       0     16)

       ''COMP TIME FOR ROUTINE 155
V386 = DFN (G1600)(
     0.0024     0
     0.096      1)

       ''LENGTH FOR MESSAGE 39
V387 = DFN (X(V107)  P7)(
     32         91     1
     20         91     2
     32         91     3
     20         91     4
      6        171     1
     12        171     2
      6        171     4
     14        180     1
      8        180     4)

       ''BRANCH CONDITIONS FOR KEYBOARD ACTIONS
V388 = DFN (X669)(
     20410      0      ''NULL
     20405      1      ''OPS CHANGE
     20420      2      ''SPEC FUNCTION
     20430      3      ''DISPLAY
     20440      4      ''ITEM DEF.
     20410      6)      ''OTHER ACTIONS

       ''LENGTH FOR MESSAGES 84 & 85
V389 = DFN (G1601)(0    0    4    1)

       ''COMP TIME FOR ROUTINE 304
V390 = (0.09 + V391) * 0.48

V391 = 0.01 + X674 * 0.38

       ''LENGTE FOR MESSAGE 41
V392 = 26 - P7$3*2 - P7$4*4

       ''SINK FOR MESSAGE 42
V393 = 60014 + P8$2*2

       ''COMP TIME FOR ROUTINE 312
V394 = DFN (X657)(
```

```
      0.25      1
      0.075     2
      0.116     3
      0.316     4
      0.105     5
      0.098     6
      0.238     7
      0.129     8
      0.128     9
      0.22     10
      0.093    11
      0.154    12)

         ''LENGTH FOR MESSAGE 45
V395 = 32 + P7$2*10 - P7$3*4

         ''LENGTH FOR MESSAGE 47
V396 = DFN (X(V107) P7)(
      2       49       1
      4       91       1
     28      110       1
     26      110       3
     22      110       4
      2      119       1
      4      165       1
      2      183       1
     16      193       1)

         ''LENGTH FOR MESSAGE 53
V397 = DFN (X(V107))(
     14       50
      8       70
      6      182)

         ''LENGTH FOR MESSAGES 64, 65, 66, 67
V398 = DFN (X(V107) G1604)(
     14       60       0
     10       62       0
      6       64       0
      0       91       0
      4       91       1
      6      114       0
      4      161       0)

         ''MASS MEMORY ACCESS TIME
V399 = X44 + V400


V400 = CFN (RF1)(
      0        0
```

```
   100       0.1
   500       0 2
  1000       0.3
  1600       0.4
  2300       0.5
  3100       0.6
  4000       0.7
  5000       0.8
  6200       0.9
  7500       0.99)

      ''GO/NOGO SETTING FOR JOBS 2, 3, 4, & 5
V401 = DFN (V402)(0  -1  1  0  0  1)

V402 = X568 - X(V107)

      ''MATRIX FOR OMS FIRE SEQ OPS
V403 = DFN (X646  X647)(
    0       0       0
    1       1       0
    2       2       0
    3       4       0
    0     128       0
    1     256       4
    2     256       8
    3     256      16
    0     256     128)

       ''REDUCTION FACTOR COUNTDOWN
V404 = X3256$X3277

      ''COMP TIME FOR ROUTINE 219
V405 = X44 + X656'2*X45

       ''INTERVAL FOR COUNTDOWN
V406 = X3277$'V355

      ''TERMINATING EVENT DETERMINATION
V407 = X(P10) - P11

      ''GO/NOGO FOR TASK 183
V408 = DFN (X685 V403)(
     0     0     0
     1     0     2)                ''INCLUDES ALL "1" SETTINGS FOR X685

       'TASK NUMBERS FOR CONDITIONAL PRINCIPAL FUNCTIONS
V409 = DFN ()(
     165
      36
     116
```

```
      115
      182
       65
       64
      201
      175
       97
      188
      190
      193
      164
       92
       54
      333
      171
       45
      183
      161
       70
       19
       15
      168
        8
        7
        6
      197
      210
      501
      502
      503
      504
      505
      506
      507
      508
      601)

       ''MAJOR MODE SAVEX FOR ACTIVATION V409 TASKS
V410 = DFN ()(
      644      ''TASK 165
      645      ''TASK 36
      645      ''TASK 116
      644      ''TASK 115
      646      ''TASK 182
      645      ''TASK 65
      645      ''TASK 64
      645      ''TASK 201
      644      ''TASK 175
      643      ''TASK 97
      643      ''TASK 188
```

```
      645      ''TASK 190
      644      ''TASK 193
      644      ''TASK 164
      646      ''TASK 92
      645      ''TASK 54
      643      ''TASK 333
      645      ''TASK 171
      645      ''TASK 45
      645      ''TASK 183
      643      ''TASK 161
      645      ''TASK 70
      643      ''TASK 19
      643      ''TASK 15
      643      ''TASK 168
      646      ''TASK 8
      645      ''TASK 7
      644      ''TASK 6
      643      ''TASK 197
      646      ''TASK 210
      647      ''TASK 501
      646      ''TASK 502
      647      ''TASK 503
      647      ''TASK 504
      647      ''TASK 505
      644      ''TASK 506
      647      ''TASK 507
      647      ''TASK 508
      647)     ''TASK 601

       ''EVENT MASK FOR ACTIVATION V409 TASKS
V411 = DFN ()(
        1      ''TASK 165
       32      ''TASK 36
       64      ''TASK 116
       64      ''TASK 115
        2      ''TASK 182
       64      ''TASK 65
       64      ''TASK 64
      256      ''TASK 201
        1      ''TASK 175
      128      ''TASK 97
        4      ''TASK 188
       32      ''TASK 190
        1      ''TASK 193
       16      ''TASK 164
        2      ''TASK 92
       64      ''TASK 54
        1      ''TASK 333
      256      ''TASK 171
      256      ''TASK 45
```

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

```
      64      ''TASK 183
      32      ''TASK 161
     128      ''TASK 70
     128      ''TASK 19
     128      ''TASK 15
     128      ''TASK 168
       1      ''TASK 8
       1      ''TASK 7
       1      ''TASK 6
     128      ''TASK 197
       1      ''TASK 210
       4      ''TASK 501
       1      ''TASK 502
       4      ''TASK 503
       4      ''TASK 504
       8      ''TASK 505
       4      ''TASK 506
       8      ''TASK 507
      16      ''TASK 508
       4)     ''TASK 601

    ''MAJOR MODE SAVEX FOR TERMINATION OF V409 TASKS
V412 = DFN ()(
     645      ''TASK 165
     645      ''TASK 36
     646      ''TASK 116
     645      ''TASK 115
     646      ''TASK 182
     646      ''TASK 65
     646      ''TASK 64
     647      ''TASK 201
     647      ''TASK 175
     647      ''TASK 97
     643      ''TASK 188
     647      ''TASK 190
     645      ''TASK 193
     644      ''TASK 164
     647      ''TASK 92
     647      ''TASK 54
     644      ''TASK 333
     647      ''TASK 171
     646      ''TASK 45
     646      ''TASK 183
     643      ''TASK 161
     646      ''TASK 70
     645      ''TASK 19
     647      ''TASK 15
     647      ''TASK 168
     646      ''TASK 8
     645      ''TASK 7
```

```
      645      ''TASK 6
      647      ''TASK 197
      647      ''TASK 210
      647      ''TASK 501
      647      ''TASK 502
      647      ''TASK 503
      647      ''TASK 504
      647      ''TASK 505
      644      ''TASK 506
      647      ''TASK 507
      647      ''TASK 508
      647)     ''TASK 601

       ''EVENT MASK FOR TERMINATION OF V409 TASKS
V413 = DFN ()(
      256      ''TASK 165
      256      ''TASK 36
        1      ''TASK 116
        1      ''TASK 115
       64      ''TASK 182
       32      ''TASK 65
       32      ''TASK 64
      512      ''TASK 201
      512      ''TASK 175
      512      ''TASK 97
        8      ''TASK 188
      512      ''TASK 190
        1      ''TASK 193
       32      ''TASK 164
        1      ''TASK 92
      512      ''TASK 54
        1      ''TASK 333
      512      ''TASK 171
        1      ''TASK 45
       64      ''TASK 183
       64      ''TASK 161
      128      ''TASK 70
       32      ''TASK 19
      512      ''TASK 15
      512      ''TASK 168
      256      ''TASK 8
       32      ''TASK 7
        1      ''TASK 6
      512      ''TASK 197
      512      ''TASK 210
      256      ''TASK 501
        1      ''TASK 502
      128      ''TASK 503
      128      ''TASK 504
      256      ''TASK 505
```

```
       8      ''TASK 506
      64      ''TASK 507
     128      ''TASK 508
     256)     ''TASK 601

      ''40 MS TIME SLICE COUNTER FOR V438
V414 = X656'12

      ''CYCLIC INTERVAL SAVEX NUMBERS OF ACTIVATED TASKS
V415 = DFN (P4)(
     3273      6
     3271      7
     3272     15
     3274     19
     3261     36
     3263     45
     3261     50
     3262     54
     3261     60
     3263     70
     3261     91
     3264     95
     3263     97
     3270    101
     3262    114
     3261    115
     3263    161
     3261    164
     3263    168
     3262    171
     3261    175
     3262    180
     3261    181
     3263    183
     3261    188
     3271    197
     3261    201
     3275    206
     3271    210
     3261    306
     3268    311
     3269    312
     3264    319
     3268    332
     3261    333
     3276    334
     3267    335
     3270    337)

      ''MULTIPLE START MATRIX FOR APPROPRIATE TASKS
```

```
V416 = DFN (P6)(
       0       6
       1       8
       0      15
       2      19
       0      36
       3      64
       4      65
       0      70
       5      92
       0      95
       6     161
       0     164
       7     182
       8     183
       0     188
       9     502
       0     503)

      ''DETERMINE MET TIME
V417 = C1 - X662

      ''DETERMINE STATE VECTOR CHANGE
V418 = (X(P8)|P9)|(X(P8)|P9)

V419 = (X(P10)|P11)|(X(P10)|P11)

      ''SYNCHRONIZATION OF FUNCTION START WITH RUN START
V420 = V445/V445 * X(V415) - V445

      ''TASK NUMBER OF INITIALLY OPERATING PRINCIPAL FUNCTIONS
V421 = DFN ()(
     181
     176
      62
      60
      41
      50
     203
      52
     120
     119
      42
     114
      49
      95
     206

     307          ''SECOND BLOCK FOR CONTINUOUS TASKS
     306
```

```
     309
      40
      91
     180
     332
     319
     110
     102
     101
     337
     335)

      ''TERMINATE MAJOR MODE SAVEX CELL INDEX FOR TASKS IN V421
V422 = DFN ()(
     646      ''TASK 181
     645      ''TASK 176
     645      ''TASK 62
     646      ''TASK 60
     645      ''TASK 41
     646      ''TASK 50
     645      ''TASK 203
     646      ''TASK 52
     645      ''TASK 120
     646      ''TASK 119
     645      ''TASK 42
     644      ''TASK 114
     646      ''TASK 49
     646      ''TASK 95
     646)     ''TASK 206

      ''TERMINATE EVENT MASKS FOR TASKS IN  V421 (GROUP 2 TASKS)
V423 = DFN ()(
     128      ''TASK 181
      64      ''TASK 176
       1      ''TASK 62
     128      ''TASK 60
       1      ''TASK 41
     128      ''TASK 50
       1      ''TASK 203
     128      ''TASK 52
       1      ''TASK 120
     128      ''TASK 119
       1      ''TASK 42
       1      ''TASK 114
     128      ''TASK 49
     128      ''TASK 95
       1)     ''TASK 206

        ''SINK FOR MESSAGE 71
V424 = 70013 +P8
```

```
      ''HALF CYCLIC INTERVAL DETERMINATION
V425 = X(V415)$2 + 10

        ''LENGTH FOR MESSAGES 79, 80, 81, 82
      ''GATE 1604 IS INDICATION OF FAULTY THRUSTER (1 = YES)
V426 = DFN (G1604  X(V107))(
     0       0       91
     4       0      161)

        ''LENGTH FOR MESSAGE 43
V427 = DFN (G1602)(0    0    2    1)

      ''SET TIME SLICE COUNTER FOR X688
V428 = X656'4

      ''COMP AS FN(40MS CTR)
V429 = (1 - X656'X45/(X656'X45)) * X44

      ''COMP TIME FOR ROUTINE 116
V430 = V429 + 1.306

      ''COMP TIME FOR ROUTINE 313
V431 = DFN (X669)(
      0.2       0
      1.204     1        ''OPS
      1 56      2        ''SPEC
      2.51      3        ''DISPLAY
      0.662     4        ''ITEM
      0 396     8        ''PRO & EXEC
      0.2      10)       ''MSG RESET

      ''COMP TIME FOR ROUTINE 149
V432 = DFN (X669)(
      0 384     0
      1 104     1)

       ''MSG LENGTH FOR DEU DISPLAY IMAGE
V433 = DFN (X669)(
      0        0
    1024       1
      0        6
    1024       8
      0       10)

       ''MSG LENGTH FOR KEYBD INP
V434 = DFN (X669)(
      0        0
     10        1)
```

```
       ''COMP TIME FOR ROUTINE 314
V435 = X44*3 + X45*X674

      ''ADDITION FOR COUNTER X659
V436 = X577$X577

        ''LENGTH FOR MESSAGES 69, 70, 71, 72
V437 = DFN (G1603  X(V107))(
     0      0       0
    24      1     114
     6      1     115
     4      1     116
     6      1     164)

      ''PART OF V347, V348 & V349 - MATRIX FOR COMP TIME ROUTINE 206
V438 = DFN (V414 X645)(
     1       0      0
     2       0      1
     3       0      2
     4       0   1024
     5       1      0
     7       1      1
     6       1      2)

      ''CONDITION FOR CLEARING X671 KEYBD INPUT
V439 = X671 * X695

      ''COMP TIME FOR ROUTINE 206
V440  = V347 + V348 + V349 + 0.329

      ''COMP TIME FOR ROUTINE 11 - SELECTION FILTERING
V441 = DFN (X(V107))(
    0.108      40
    0.072      42
    0.025      45
    0.312      49
    0.145     120
    0.24      171)

       ''SECONDS OF SIMULATED OPERATIONS FOR REPORT 2
V442 = (C1 - X642)*X90/1000

       ''CURRENTLY EXECUTING FUNCTIONS
V443 =  B1184

       ''ASSIGNED CORE MEMORY
V444 = 70001

      ''PART OF V420 - SYNCHRON OF FUNCTION START
V445 = (C1 - X642)'X(V415)
```

```
      ''COMP TIME FOR ROUTINE 159
V446 = DFN (X(V107))(
    0.338      40
    0.203      41
    0.258      42
    0 034      49
    0.164      52
    0.088      54
    0.18       65
    0.517     101
    0.852     102
    2.057     110
    0.38      119
    0.416     120
    0.491     180
    0.48      203
    0.214     337)

      ''PART OF V349 - COMP TIME FOR ROUTINE 206
V447 = (V438$7*0.571 + (1 - V438$5 +V438$7)*0.56*RF1)*0.48

      ''COMP TIME FOR ROUTINE 221
V448 = DFN (X(V107)  G5210  X647)(
     0.10     206      0      0
     0.60     210      0      0
     0.24     210      1      0
     0.05     210      1    256)

      ''COMP TIME FOR ROUTINE 220
V449 = X656'4 * 0.01 - X656'4$2*0.02 + X656'4$3*0.02

''  B   ********** IMSIM 04B REVISIONS **********

       ''CORRECTS PROPER UTILIZATION TIME
V9 = FT(IC2)/(C1 - X642)*100$1

      ''CORRECT USE COUNT FOR RECYCLED TASKS
V33 = DFN (X632)(1400  0  1352  1  1355  100000)

      ''SYNC OF MSG WITH TASK EXECUTION
V45 = X(V47)*100 + G(V40)

V109 = DFN(V45 V162)( 1 0 0   0 0 1   1 1 0 )

V162 = X(V42) + X(V46)

      ''FOR COMP TIME LESS THAN 1 MS
V195 = P3/X100 + RF1
```

```
      ''RESPONSE MSG AS NATURE -1
V212 = DFN (P7  P6)(
    1878    -1    0
    1865    -1    1
    1878    -1    2
    1844     0    0
    1865     0    1
    1855     0    2)

       'RESPONSE MSG AS NATURE -1
V249 = DFN (P7)(1678  0    1679  1    1677  2)

      ''CORRECTS TRIGGERING MSG RESPONSE
V251 = X(V102)$10000

V252 = DFN (G(V42)  V251)(0 0 0   1 0 5   0 0 6   1 1 0)

      ''CORRECT ROUNDING ERROR MEMORY TRANSMISSION RATE
      ''THIS VARIABLE HAS BEEN INCORPORATED IN THE NASA.SPECS50.DATA FILE
''V259 = (P3*1000 + 0.5)$1

      ''TASK ASSOCIATED GATE
V299 = 5000 + X(V107)

      ''PRINCIPAL FUNCTIONS TASK GENERATION
20000 GEN   0   0   X639   0   50 ''START TRANSACTIONS FOR PRINCIPL FNCS
      ADMIT IF X3255 LS X3254 ''ADMIT ONLY NUMBER OF ENTRIES IN V409
      X3255 + 1               ''COUNTER STARTING AT 0
      A10 = X3255
      P1 = 416                ''SET VARIABLE NUMBER FOR MULTIPLE STARTS
      P4 = V409               ''DETERMINE TASK NUMBER
20010 P6 = V409               ''FOR A10 MULTIPLE START INDEX
      P8 = V410               ''MAJOR MODE START CONDITION
      P9 = V411               ''EVENT MASKS START CONDITION
      P10 = V412              ''MAJOR MODE TERMINATE CONDITION
      P11 = V413              ''EVENT MASKS TERMINATE CONDITION
      P12 = 1                 ''FIRST PASS INDICATOR
20013 DETOUR 20018            ''WAIT FOR ACTIVATION CONDITION
      ADMIT IF V364 GE 0      ''START TASK ACTIVATION IMMEDIATELY
20014 DETOUR 20015            ''START OF CYCLIC OPERATIONS
      ADMIT IF V407 GE 0      ''TERMINATE CONDITION
      DETOUR 20020            ''FOR MULTIPLE START FUNCTIONS
      ADMIT IF V(P1) = 0      ''ONCE ONLY START FUNCTIONS
20017 REMOVE                  ''ALL DONE
20015 ADMIT IF X568 = 0       ''ACTIVATION ROUTINE
      X568 = P4               ''SET TASK ACTIVATION SAVEX
      X577 = P4               ''SET FUNCTION NUMBER
      PRINT R 31 31           ''GO MSG FOR TASK
      PR1 + 0                 ''PROCESS FUNCTION ACTIVATION
      X568 = 0                ''RESET SAVEX
```

```
      PRINT R 30 30           ''FUNCTION ABORT REPORT
      X659 + V436             ''ABORT COUNTER
      X577 = 0                ''RESET FUNCTION NUMBER AFTER ABORT
      DETOUR 20019            ''NORMAL CYCLIC INTERVAL
      ADMIT IF P12 = 1        ''SYNCHRONIZE 1ST PASS
      P12 = 2                 ''PREVENT NEXT PASS
      DETOUR 20019            ''TO NORMAL INTERVAL
      ADMIT IF V420 GR V425   ''SYNC ONLY IF TIME OVER HALF
      DELAY V420              ''SYNCHRONIZE FUNCTION
      TRY 20014               ''NEXT TIME CYCLIC OPERATION
20019 DELAY X(V415)           ''CYCLIC INTERVAL FOR ACTIVATION
      TRY 20014               ''NEXT CYCLIC OPERATION
20018 SAVE X(P8)              ''STATE VECTOR/MAJOR MODE
      ADMIT IF X(P9) NE P6
      POP                     ''RESTORE STACK
      TRY 20013
20020 A10 = V416
      A10 + X3254
      TRY 20010               ''MULTIPLE START FUNCTIONS
20030 GEN   0   0   X638   13   50 ''CONTINUOUS TASKS
      X3251 + 1               ''START AT X3253
      A10 = X3251             ''FOR INDEX INTO V421
      P4 = V421
20035 ADMIT IF X568 = 0
      X568 = P4               ''SET TASK ACTIVATION SAVEX
      X577 = P4               ''SET FUNCTION NUMBER
      PR1 + 0                 ''PROCESS FUNCTION ACTIVATION
      PRINT R 31 31           ''GO MSG FOR TASKS
      X568 = 0                ''RESET SAVEX
      PRINT R 30 30           ''FUNCTION ABORT REPORT
      X659 + V436             ''ABORT COUNTER
      X577 = 0
      DELAY X(V415)           ''CYCLIC INTERVAL FOR ACTIVATION
      TRY 20035               ''FOR CONTINUOUS CYCLIC OPERATION
20040 GEN   0   0   X638   0   50 ''INITIAL TASKS THAT TERMINATE
      ADMIT IF X3252 LS X3253
      X3252 + 1               ''START AT 0
      P1 = 10                 ''NO REPEATING TASKS (V10=0)
      A10 = X3252             ''FOR INDEXING INTO TERMINATE CONDITS
      P4 = V421               ''DETERMINE TASK NUMBER
      P10 = V422              ''MAJOR MODE TERMINATE CONDITION
      P11 = V423              ''EVENTS MASKS TERMINATE CONDITION
      P12 = 2                 ''PREVENT SYNCHRONIZATION DELAY
      TRY 20015               ''TASK ACTIVATION
20400 GEN  X3276  0   X641   0   50 ''GENERATE FOR USER INTERFACE
      ADMIT IF X669 GE 1      ''KEYBOARD ACTION
      ADMIT IF X568 = 0
      X568 = 334              ''SET FUNCTION ACTIVATE SAVEX
      X577 = 334              ''SET FUNCTION NUMBER
      PR1 + 0                 ''PROCESS ACTIVATION USER INTERF.
```

```
      PRINT R 31 31           ''GO MSG FOR TASKS
      X568 = 0                ''RESET SAVEX
      PRINT R 30 30           ''FUNCTION ABORT
      X659 + V436             ''ABORT COUNTER
      X577 = 0
20402 DELAY 1
      COPY TO V388            ''PROCESS KEYBOARD ACTIONS
      X669 = 0                ''CLEAR KEYBOARD
      X670 = 0                ''HOUSEKEEP SPEC FUNCTION
      X671 = 0                ''HOUSEKEEP ITEM INPUTS
      TRY 20410
20405 DETOUR 20410
      ADMIT IF X663 NE X666   ''GN&C MODE CHANGE
      X666 = X663             ''MAINTAIN CURRENT GN&C MODE
20410 REMOVE
20420 DETOUR 20410
      ADMIT IF X670 NE 0
      DELAY 1                 ''FOR CODE SPEC FUNCTIONS
      TRY 20410
20430 DETOUR 20410
      ADMIT IF X671 NE 0
      X674 = 2                ''FOR DISPLAY FUNCTIONS
      TRY 20410
20440 DETOUR 20410
      ADMIT IF X671 NE 0
      DELAY 1                 ''FOR CODE ITEM ENTRIES
      TRY 20410

      ''GENERATE EVENT MASKS FOR EACH MAJOR MODE
      ''SET X643 = 1 IN INITIAL CONDITIONS
30000 GEN  X3278  0  X698  0  50
      ADMIT IF C1 GE X3277      ''IN MM101 THRU JOBSCHEDULE
30010 DETOUR 30015
      ADMIT IF X644 = 0         ''FIRST TIME AROUND
      X644 = 1                  ''SET FIRST EVENT
      X663 = 102                ''SET MAJOR MODE 102
30003 X3280 = 1                 ''EVENT COUNTER FOR RPT 40
30004 PRINT R 40 40             ''PRINT EVENT OCCURRENCE RPT
30005 REMOVE
30015 DETOUR 30020              ''IF NOT MM 102
      ADMIT IF X644 LE 256
      X644 + X644               ''SET NEXT EVENT
30019 X3280 + 1                 ''INCREASE EVENT COUNTER
      TRY 30004
30020 DETOUR 30025
      ADMIT IF X645 = 0         ''FIRST TIME AROUND
      X645 = 1                  ''SET FIRST EVENT
      X663 = 103                ''SET MAJOR MODE 103
      TRY 30003
30025 DETOUR 30030              ''IF NOT MM103
```

```
      ADMIT IF X645 LE 512
      X645 + X645                ''SET NEXT EVENT
      TRY 30019
30030 DETOUR 30035
      ADMIT IF X646 = 0          ''FIRST TIME AROUND
      X646 = 1                   ''SET FIRST EVENT
      X663 = 104                 ''SET MAJOR MODE 104
      TRY 30003
30035 DETOUR 30040
      ADMIT IF X646 LE 128
      X646 + X646                ''SET NEXT EVENT
      TRY 30019
30040 DETOUR 30045
      ADMIT IF X647 = 0          ''FIRST TIME AROUND
      X647 = 1                   ''SET FIRST EVENT
      X663 = 105                 ''SET MAJOR MODE 105
      TRY 30003
30045 DETOUR 30050               ''IF NOT MM 105
      ADMIT IF X647 LE 128
      X647 + X647                ''SET NEXT EVENT
      TRY 30019
30050 X663 = 106                 ''SET MAJOR MODE 106
      TRY 30019

      ''COUNTDOWN CLOCK IN TENTHS OF SECONDS
      ''S X3256 = 20000  INITIAL CONDITIONS
30500 GEN   X3257   0   0   X638   50
      ADMIT IF X661 NE 0          ''START COUNTDOWN
      DETOUR TO 30508
      ADMIT IF X675 NE 1          ''NOT IN HOLD COUNTDOWN
      PRINT R 38 38               ''PRINT COUNTDOWN TIME REPORT
      X661 - 1                    ''COUNTDOWN
30505 DETOUR 30510
      ADMIT IF X661 = 0           ''LAST COUNTDOWN GENERATION
      DELAY X3260
      X662 = C1                   ''START MET
      PRINT R 38 38               ''LAST COUNTDOWN REPORT
      TRY 30510
30508 PRINT R 36 36               ''PRINT HOLD COUNT REPORT
      X3258 = 0                   ''PRINT ONLY ONCE
30510 REMOVE

      ''DETERMINE 40 MS & 80 MS TIME SLICE
30700 GEN  40   0   X638   0   50
      X656 + 1                    ''SET 40 MS COUNTER
      X660 = V371                 ''SET TIME SLICE
      DETOUR 30710                ''IF NOT 80 MS
      ADMIT IF V372 = 0           ''80 MS SLICE
      X657 = V377                 ''SET 80 MS COUNTER
      X688 = V428
```

```
30710 REMOVE

      ''SET CYCLIC INTERVAL CHANGES FOR TASKS 6, 19 & 206
30800 GEN   0   0   X638   1   50
      P1 = 30801                ''RETURN BLOCK FOR RT 30820
      P8 = 644                  ''MAJOR MODE 102
      P9 = 1                    ''EVENT 19
30801 DETOUR 30820
      ADMIT IF V364 GE 0        ''CHANGE CYCLIC INTERVAL
      X3274 = 160               ''INTERVAL NOW 160 MS FOR TASK 19
      P1 = 30802                ''RETURN BLOCK FOR RT 30820
      P9 = 2                    ''EVENT 21
30802 DETOUR 30820
      ADMIT IF V364 GE 0        ''CHANGE CYCLIC INTERVAL
      X3273 = 500               ''INTERVAL NOW 500 MS FOR
      X3274 = 500               ''TASKS 6 & 19
      P1 = 30803                ''RETURN BLOCK FOR RT 30820
      P8 = 645                  ''MAJOR MODE 103
      P9 = 1                    ''EVENT 28
30803 DETOUR 30820
      ADMIT IF V364 GE 0        ''CHANGE CYCLIC INTERVAL
      X3274 = 2000              ''INTERVAL NOW 2000 MS FOR TASK 19
      P1 = 30804                ''RETURN BLOCK FOR RT 30820
      P9 = 16                   ''EVENT 31
30804 DETOUR 30820
      ADMIT IF V364 GE 0        ''CHANGE CYCLIC INTERVAL
      X3274 = 500               ''INTERVAL NOW 500 MS FOR
      X3275 = 500               ''TASKS 19 & 206
      P1 = 30805                ''RETURN BLOCK FOR RT 30820
      P9 = 32                   ''EVENT 32
30805 DETOUR 30820
      ADMIT IF V364 GE 0        ''CHANGE CYCLIC INTERVAL
      X3274 = 2000              ''INTERVAL NOW 2000 MS FOR TASK 19
      REMOVE                    ''ALL DONE
30820 SAVE X(P8)                ''STATE VECTOR/MAJOR MODE
      ADMIT IF X(P9) NE P6      ''STATE VECTOR CHANGED
      POP                       ''RESTORE STACK
      TRY P1                    ''FOR CYCLIC CHANGE CHECK

      ''REDUNDANT SET LAUNCH SEQUENCE PROCESSING LOGIC (TASK 114)
40000 GEN   0   0   0   1   63
      ADMIT IF X643 GE 16       ''EVENT 11
      G1603 = 1                 ''SET GATE TO ALLOW MESSAGE TRAFFIC
      ADMIT IF X643 GE 2048     ''EVENT 19
      G1603 = 0                 ''RESET GATE TO PREVENT TRANSMISSION
      DETOUR 40010              ''RANGE SAFETY LOGIC
      ADMIT IF X644 GR 16       ''EVENT PASSED
      DETOUR 40020              ''SRB SEPARATION LOGIC
      ADMIT IF X644 GR 128      ''EVENT PASSED
      DETOUR 40030              ''ET SEPERATION LOGIC
```

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      ADMIT IF X645 GR 64       ''EVENT PASSED
      DETOUR 40035              ''CONTINUED ET SEP LOGIC
      ADMIT IF X645 GR 128      ''EVENT PASSED
      REMOVE
      ''RANGE SAFETY LOGIC (TASK 164)
40010 ADMIT IF X644 = 16        ''EVENT 24
      G1603 = 1                 ''ALLOW MESSAGE TRANSMISSION
      DELAY 40
      G1603 = 0                 ''RESET GATE TO TERMINATE XMIT
      ''SRB SEPARATION SEQUENCER LOGIC (TASK 115)
40020 ADMIT IF X644 = 128       ''EVENT 26
      G1603 = 1                 ''ALLOW TRANSMISSION MESSAGES
      ADMIT IF X644 = 256       ''EVENT 27
      DELAY 40
      G1603 = 0                 ''TERMINATE TRANSMISSION
      ''ET SEPARATION SEQUENCE LOGIC (TASK 116)
40030 ADMIT IF X645 = 64        ''EVENT 33
      G1603 = 1                 ''ALLOW MSG TRANSMISSION FOR 69 - 72
      G1601 = 1                 ''ALLOW MSG 84, 85 TRANSMISSION
      G1602 = 0                 ''OFF FOR MSG 43
      ADMIT IF X537 = 50084     ''MESSAGE 84 COMPLETED
      G1601 = 0                 ''OFF FOR MSG 84 & 85
40035 ADMIT IF X645 = 128       ''EVENT 33A
      G 1603 = 1                ''ALLOW MESG TRANSMISSION FOR 69 - 72
      DELAY 125                 ''FOR PREVALVE CLOSE
      X686 = 1                  ''MPS VALVES CLOSED
      DELAY 50                  ''ONE SEC RT
      G1601 = 1                 ''ON FOR MESSAGES 84 & 85
      ADMIT IF X537 = 50084     ''MESSAGE 84 COMPLETE
      G1601 = 0                 ''OFF FOR MSG 84 & 85
      DELAY 150                 ''4920 MS RT
      G1602 = 1                 ''ON FOR MESSAGE 43
      ADMIT IF X537 = 50043     ''MESSAGE 43 COMPLETED
      G1602 = 0                 ''RESET GATE
      DELAY 80
      G1603 = 0
      REMOVE

      ''OMS FIRE SEQUENCE GEN
40050 GEN   0   0   X639   2   51
40051 ADMIT IF V403 GE 1        ''DETERMINE FIRE SEQ
      X683 = V403               ''SET SAVEX SEQ.
      DELAY 40
      DETOUR 40051
      ADMIT IF V403 = 0
      REMOVE

      ''FAULTY THRUSTER MONITOR
40100 GEN   0   0   0   1   63
      ADMIT IF X690 NE 0        ''FAULTY INDICATOR
```

```
      G1604 = 1                ''SET GATE FOR FAULTY THRUSTER
      DELAY 40
      G1604 = 0
      REMOVE

      ''EVENT RELATED REPORT GENERATION
40200 GEN   0   0   0   0   50
      ADMIT IF X663 NE X666
      PRINT R 35 35
      X666 = X663
      REMOVE
40220 GEN   0   0   0   0   50
      ADMIT IF X685 NE 0
      PRINT R 37 37
      X3259 = 0
      REMOVE

''  C,  ********************** NASA UNIQUE REPORTS ***************

REPORT 2 1 1
 DURING V442    SECONDS OF SIMULATED SHUTTLE OPERATIONS
 A TOTAL OF BW1160 DIFFERENT FUNCTIONS WERE INTRODUCED.
 THESE FUNCTIONS WERE ACTIVATED BW1166 TIMES, STATUS IS
       BW1196 WERE COMPLETED
        B1167 ARE WAITING FOR NEXT ACTIVATION
        B3032 ARE IN READY STATE, I.E. WAITING FOR CPU
        B1182 ARE WAITING FOR MESSAGES TO COMPLETE
         V443 PRESENTLY EXECUTING, I.E. IN ACTIVE STATE
 FUNCTIONS WERE INTERRUPTED BW2000 TIMES.
  X659 FUNCTION ACTIVATIONS WERE ABORTED AS FUNCTION STILL ACTIVE. ENDR

REPORT 3 1 1 0
NOT APPLICABLE FOR NASA.  ENDR
REPORT 30 1 1 X577
                      *** ABORTED ***  ENDR
REPORT 31 1 1 G43
      C1 TUS    TG     GO FOR     TASK      P4 ENDR

REPORT 35 1 1
 **AT TIME     C1 TRANSITION TO MAJOR MODE X663 OCCURRED. ENDR

REPORT 36 1 1 X3258
 **AT TIME     C1 COUNTDOWN STOPPED DUE TO HOLD COUNT COMMAND,
   COUNTDOWN CLOCK IS STOPPED AT - X661 SECONDS. ENDR

REPORT 37 1 1 X3259
 **AT TIME     C1 FROM START, OMS ENGINE FAILURE OCCURRED AT
   MISSION ELAPSED TIME (MET)   V417   ENDR

REPORT 38 1 1 X3258
```

```
 ** AT TIME      C1 COUNTDOWN CLOCK IS AT - X661 SECONDS AND COUNTING. ENDR

REPORT 40 1 1 X3258
 ** AT TIME    C1 , EVENT X3280 IN MAJOR MODE X663 OCCURRED. ENDR

''
''  D. ************ IMSIM LOGIC CHANGES ****************
''

REVISE 14000 14000              ''SPEED-UP BY ELIMINATING PROTOTYPES
      P1 + 0

REVISE 220000
      TALLY 1 1                 ''COUNT TASK ACTIVATIONS FOR SUMMARY

TABLE 1 = P5 706 1 800          ''TASK ACTIVATION SCORES

REVISE 226000                   ''SYNC OF MSG WITH TASK EXECUTION
      DETOUR 1182
      ADMIT IF V45 GT 0

REVISE 242000 250000            ''SYNC OF MSG WITH TASK EXECUTION
1186  G(V40) = 0
      PR1 + 0
      DETOUR 1186
1192  ADMIT IF G(V40) = 0

REVISE 263000 263000            ''CORRECT TASK CLEANUP AT TERMINATION
1198 DELAY 1
     X(P9) + P2

REVISE 269000 273000            ''SYNC OF MSG WITH TASK EXECUTION
      ADMIT IF V45 = 0

REVISE 278000 285000            ''SYNC OF MSG WITH TASK EXECUTION
1182 DETOUR 1196
      ADMIT IF V162 NQ 0
      PRINT R 26 26
      ADMIT IF V109 = 1

REVISE 287000
      G(V299) = 1

REVISE 294000 294000            ''ELIMINATE PROC FOR TASK INITIATION
      COPY TO 1209

REVISE 437000 447000            ''SPEED-UP BY ELIMINATING V.M. & MEMORY
      TRY 1352

REVISE 449000 466000            ''SPEED-UP BY ELIM. V.M. & MEM. RECORDING
```

```
      X(V67) = 1

REVISE 590000                    ''CORRECT FAULTY RESPONSE MSG
      DETOUR 1510
      ADMIT IF V65 = 5
      P6 = -1

REVISE 660000 660000             ''SYNC OF MSG WITH TASK EXECUTION
1603  DETOUR 1609
      ADMIT IF V252 = 0
      ADMIT IF G(V40) = 0
      G(V40) = 1
      ADMIT IF G(V40) = 0

REVISE 704000 704000             ''CORRECT FAULTY RESPONSE MSG
1670  PR1 = 55

REVISE 718000 718000             ''CORRECT FAULTY RESPONSE MSG
1674  P3 = V232

REVISE 719000 719000             ''CORRECT FAULTY RESPONSE MSG
      TRY V249
1677  COPY TO 1679
      P7 - 1
      PR1 = 53
      TRY 1670
1678  COPY TO 1679
      PR1 = 53
      TRY 1670
1679  PR1 = 52

REVISE 724000                    ''CORRECT FAULTY RESPONSE MSG
      P4 = P3

REVISE 901000 902000             ''COMPLETE MSG TRANSM AT TASK TERMINATION
1826 COPY TO V212

REVISE 905000 905000             ''PREVENT COMP TIME FROM MESSAGES
      ADMIT IF X(P2) = 1

REVISE 926000 926000             ''CORRECT FAULTY RESPONSE MSG
      ADMIT IF P7 LE 0

REVISE 983000 989000             ''SYNC OF MSG WITH TASK EXECUTION
1847   TRY 1603

REVISE 997000 997000             ''CORRECT FAULTY RESPONSE MSG
      ADMIT IF P7 LE 0

REVISE 1075000 1075000           ''CORRECT TASK CLEANUP AT TERMINATION
```

```
REVISE 1080000 1080000          ''SYNC OF MSG WITH TASK EXECUTION

REVISE 1225000 1225000          ''CORRECT USE COUNT FOR RECYCLED TASKS
5456 X632 = 100000

REVISE 1404000 1404000          ''CORRECT FAULTY RESPONSE MSG
9000  PR1 = 54

''
''
''  E.  ****************** INITIAL CONDITIONS ******************
''
S X642 = 100                ''REFERENCE TIME FOR SIMULATION START
S X640 = X642 - 2           ''COMMUNICATION REGISTER FOR COORD START TIMES
S X638 = X640               ''START TIME FOR CONTINUOUS FUNCTIONS
S X639 = X640               ''START TIME FOR TERMINATING FUNCTIONS
S X641 = X640               ''START TIME USER INTERFACE FUNCTION
S X643 =  1                 ''MAJOR MODE 101, EVENT 6
S X662 = 9999999            ''MET CLOCK PRIOR TO LIFTOFF
S X663 = 101                ''GN&C OPS 1 - MAJOR MODE 101
S X666 = 101                ''CURRENT GN & C MODE
S X672 =  1                 ''NAV STATE· AUTO-P
S X673 = 001                ''IMU PLATFORM RELEASED
S X694 =  1                 ''DOWNLIST ENABLED
S X697 =  1                 ''TIME MANAGEMENT ENABLED
S X698 =  X640              ''START TIME FOR EVENT MASK GENERATION
S X3253 = 15                ''NUMBER OF FUNCTIONS GENERATED BY 20040
S X3251 = X3253             ''INDEXING INTO BLOCK 2 OF V421
S X3254 = 30                ''NUMBER OF FUNCTIONS TO BE GEN IN V409
S X3256 = 20000             ''COUNTDOWN CLOCK IN MS (-20.000 SEC)
S X3277 = 2000              ''JOBSCHEDULE START FOR MM 102
S X3257 = V406              ''INTERVAL FOR COUNTDOWN COUNTER/FNC OF X3256
S X3260 = X3257             ''DELAY FOR LAST COUNTDOWN
S X661  = V355              ''INITIAL COUNTDOWN COUNTER/FNC OF X3277
S X3258 = 1                 ''PRINT REPORT 36 WHEN APPROPRIATE
S X3259 = 1                 ''PRINT REPORT 37 WHEN APPROPRIATE
S X3261 = 40                ''40 MS CYCLIC INTERVAL
S X3262 = 80                ''80 MS CYCLIC INTERVAL
S X3263 = 160               ''160 MS CYCLIC INTERVAL
S X3264 = 320               ''320 MS CYCLIC INTERVAL
S X3265 = 960               ''960 MS CYCLIC INTERVAL
S X3266 = 50                ''50 MS CYCLIC INTERVAL
S X3267 = 100               ''100 MS CYCLIC INTERVAL
S X3268 = 200               ''200 MS CYCLIC INTERVAL
S X3269 = 500               ''500 MS CYCLIC INTERVAL
S X3270 = 1000              ''1000 MS CYCLIC INTERVAL
S X3271 = 2000              ''2000 MS CYCLIC INTERVAL
S X3272 = 4000              ''4000 MS CYCLIC INTERVAL
S X3273 = 160               ''160/500 MS CYCLIC INTERV CHANGE (TASK 6)
```

```
S X3274 = 2000          ''2000/160/500/2000/500/2000 MS CYCL.CHANGE (19)
S X3275 = 2000          ''2000/500 MS CYCLIC INTERVAL CHANGE (TASK 206)
S X3276 = 2             ''2 MS CYCLIC INTERVAL (TASK 334)
S X3278 = 175           ''INTERVAL FOR EVENT GENERATION
S G43 = 1               ''FOR PRINTING TASK HISTORY
S G44 = 1               ''FOR PRINTING MESSAGE HISTORY
S A9 = 70               ''TIME-OUT CONTROL IN MINUTES
SOURCE PRIMARY
''
''
''  F.  ********INITIAL CONDITIONS FOR TRANSITION MM101 TO MM102
''
S X3256 = 1000          ''COUNTDOWN CLOCK IN MS
S X3257 = 100           ''INTERVAL FOR COUNTDOWN COUNTER
S X3260 = 1998          ''DELAY FOR LAST COUNTDOWN
S X3277 = 2000          ''JOBSCHEDULE START FOR MM102
S X3278 = 50            ''INTERVAL FOR EVENT GENERATION
S X661 = 1              ''COUNTDOWN COUNTER
S X642 = 1900           ''REFERENCE TIME FOR SIMULATION START
S X638 = 1898           'START TIME FOR CONTINUOUS FUNCTIONS
S X639 = 1898           ''START TIME FOR TERMINATING FUNCTIONS
S X640 = 1898           ''COMMUNICATION REGISTER FOR COORD START TIMES
S X641 = 1898           ''START TIME USER INTERFACE FUNCTIONS
S X698 = 1898           ''START TIME FOR EVENT MASK GENERATION
S X643 = 1024           ''SET EVENT 17 - SSME START - IN MM101
SOURCE PRIMARY
''
''
''  G.  ************ INITIAL CONDITIONS FOR TRANSITION MM102 TO MM103 ****
''
S X3256 = 0             ''COUNTDOWN CLOCK IN MS
S X3273 = 500           ''CYCLIC INTERVAL FOR TASK 6
S X3274 = 2000          ''CYCLIC INTERVAL FOR TASK 19
S X3275 = 2000          ''CYCLIC INTERVAL FOR TASK 206
S X3277 = 120000        ''START TIME FOR MM103
S X3278 = 50            ''INTERVAL FOR EVENT GENERATION
S X3280 = 27            ''EVENT COUNTER
S X661 = 0              ''COUNTDOWN COUNTER
S X662 = 120000         ''MET CLOCK START
S X663 = 102            ''GN&C OPS 1 - MAJOR MODE 102
S X666 = 102            ''CURRENT MAJOR MODE
S X642 = 120000         ''REFERENCE TIME FOR SIMULATION START
S X638 = 119998         ''START TIME FOR CONTINUOUS FUNCTIONS
S X639 = 119998         ''START TIME FOR TERMINATING FUNCTIONS
S X640 = 119998         ''COMM REGISTER FOR COORD START TIMES
S X641 = 119998         ''START TIME USER INTERFACE FUNCTIONS
S X698 = 119998         ''START TIME FOR EVENT MASK GENERATION
S X643 = 2048           ''ALL EVENTS  MM101 OCCURRED
S X644 =  256           ''SET EVENT 27 - MODING FOR SEP - IN MM102
SOURCE PRIMARY
```

APPENDIX B

NASA.SPECS50.DATA

```
''   NASA.SPECS50.DATA  -  01/12/77
''
''   SIMULATION SPECIFICATIONS FOR SPACE SHUTTLE ORBITER
''   ONBOARD DATA PROCESSING SYSTEM - OFT ASCENT PHASE
''
''   PRODUCED BY THE SYSTEM DEVELOPMENT CORPORATION
''
''   DATA ARE PREPARED ON IMSIM SPECIFICATION FORMS, AS DESCRIBED IN
''   SDC PUBLICATION TM-5328/102, "IMSIM INFORMATION MANAGEMENT SYSTEM
''   SIMULATOR USER'S MANUAL".
''
''   NASA COMMENTS ON TEST PLAN INCORPORATED 6 DEC 1976
''
'' ABBREVIATIONS USED IN THIS DOCUMENT
''
'' AA     - ACCELEROMETER ASSEMBLY
'' ABSOL  - ABSOLUTE
'' A/D    - ANALOG/DIGITAL
'' CMD    - COMMAND
'' ET     - EXTERNAL TANK
'' FDI    - FAULT DETECTION AND IDENTIFICATION
'' GN&C   - GUIDANCE NAVIGATION & CONTROL
'' GPC    - GENERAL PURPOSE COMPUTER
'' GR/EQ  - GREATER THAN OR EQUAL TO
'' IMU    - INERTIAL MEASURING UNIT
'' INIT   - INITIAL
'' INTERV- INTERVAL
'' LDB    - LAUNCH DATA BUS
'' LIB DS- LIBRARY DATA SET
'' MCA    - MOTOR CONTROL ASSEMBLY
'' MECO   - MAIN ENGINE CUTOFF
'' MET    - MISSION ELAPSED TIME
'' MM     - MAJOR MODE
'' MPS    - MAIN PROPULSION SYSTEM
'' MS     - MILLISECONDS
'' NA     - NOT APPLICABLE (TO OFT ASCENT)
'' NAV    - NAVIGATION
'' OFT    - ORBITAL FLIGHT TEST
'' OMS    - ORBITAL MANEUVERING SYSTEM
'' OPS 1  - OPERATIONAL SEQUENCE 1
'' ORG    - ORGANIZATION OF DATASET
'' PARAM  - PARAMETERS
'' PL     - PAYLOAD
'' PROC   - PROCESSING/PROCESSOR
'' RCS    - REACTION CONTROL SYSTEM
'' RELATV- RELATIVE
'' RG     - RATE GYRO
'' SEP    - SEPARATION
'' SM     - SYSTEM MANAGEMENT
'' SOP    - SUBSYSTEM OPERATING PROGRAM
```

'' SRB - SOLID ROCKET BOOSTER
'' SSME - SPACE SHUTTLE MAIN ENGINES
'' TBD - TO BE DETERMINED
'' TRX - TRANSMISSION
'' TVC - THRUST VECTOR CONTROL
'' V.M. - VIRTUAL MACHINE
''
''

	PRINCIPAL FUNCTIONS	TASK NUMBER
AASP	- ACCELEROMETER ASSEMBLY SOP	42
ADAP	- AERO-JET DIGITAL AUTOPILOT	36
ADIP	- ASCENT DISPLAY PROCESSING	206
AEAP	- AEROSURFACE ACTUATOR CMD SOP	50
AMDP	- ASCENT MANEUVER DISPLAY PROC	210
ARCP	- ASCENT REACTION CONTROL SYSTEM CMD SOP	190
ASAI	- ASCENT ATTITUDE DIRECTOR INDICATOR PROC	168
ASDP	- ASCENT DIGITAL AUTOPILOT	176
ASNS	- ASCENT NAVIGATION SEQUENCER	139
ASNV	- ASCENT NAVIGATION	15
ATTP	- ATTITUDE PROCESSING	97
AUPP	- ASCENT USER PARAMETER PROC	19
AUPS	- ASCENT USER PARAMETER PROC SEQUENCER	197
BFFD	- BODY FLAP CMD FAULT DETECTION, IDENTIFICATION	95
BFFP	- BODYFLAP POSITION FEEDBACK SOP	49
CDIP	- CYCLIC DISPLAY PROCESSOR	335
EDFP	- ELEVON DELTA PRESSURE FEEDBACK SOP	193
ETSS	- EXTERNAL TANK SEPARATION SEQUENCER	116
GAXI	- GUIDANCE, NAVIGATION & CONTROL ANNUNCIATION INTERFACE	110
GCSI	- GUIDANCE/CONTROL STEERING INTERFACE	175
GEFC	- FAST CYCLE EXECUTIVE	306
GMIN	- MINOR CYCLE EXECUTIVE	309
GPSW	- GPC SWITCH MONITOR	337
GSWP	- GUIDANCE, NAVIGATION & CONTROL SWITCH PROC	180
HYSP	- HYDRAULIC SYSTEM SOP	52
IDAP	- INSERTION DIGITAL AUTOPILOT	201
IMMC	- IMU MAJOR CYCLE EXECUTIVE	319
IMRM	- INERTIAL MEASUREMENT UNIT REDUNDANCY MANAGEMENT	72
IMUP	- IMU INERTIAL PROCESSING	38
LDBP	- LDB I/O PROCESSOR	333
MCDS	- MCDS INPUT PROCESSOR	332
MOPS	- SPACE SHUTTLE MAIN ENGINE OPERATIONS	165
MPSD	- MAIN PROPULSION SYSTEM DUMP SEQUENCER	70
MTVP	- MAIN PROPULSION SYSTEM THRUST VECTOR CONTROL CMD SOP	60
OASC	- ORBITER ACTUATOR SLEW CHECK	187
OING	- ORBIT INSERTION GUIDANCE	8
OMFS	- ORBITER MANEUVERING SYSTEM FIRING SEQUENCER	182
OMIC	- OMS-TO-OMS INTERCONNECT FUNCTION	183
OMQM	- ORBITER MANEUVERING SYSTEM QUANTITY MONITOR	101
OMSF	- OMS FAULT DETECTION AND IDENTIFICATION	92

```
'' ORGP  - ORBITER RATE GYRO SUBSYSTEM OPERATING PROGRAM                 40
'' OTFP  - OMS THRUST VECTOR CONTROL FEEDBACK SOP                        65
'' OTVP  - OMS THRUST VECTOR CONTROL COMMAND SOP                         64
'' RASP  - RADAR ALTIMETER SOP                                           45
'' RCQM  - REACTION CONTROL SYSTEM QUANTITY MONITOR                     102
'' RCSF  - RCS FAULT DETECTION AND IDENTIFICATION                        91
'' RHCP  - THREE-AXIS ROTATIONAL HAND CONTROLLER SOP                    171
'' RNGS  - RANGE SAFETY FUNCTION                                        164
'' RSLS  - REDUNDANT SET LAUNCH SEQUENCE PROCESSING                     114
'' SFIL  - SELECTION FILTERING                                           71
'' SMEM  - SPACE SHUTTLE MAIN ENGINE MONITOR FUNCTION                   119
'' SMEP  - SPACE SHUTTLE MAIN ENGINE SOP                                181
'' SRBM  - SOLID ROCKET BOOSTER MONITOR FUNCTION                        120
'' SRDA  - SOLID ROCKET BOOSTER DATA ACQUISITION                        203
'' SRGP  - SOLID ROCKET BOOSTER RATE GYRO SOP                            41
'' SRSC  - SOLID ROCKET BOOSTER ACTUATOR SLEW CHECK                     188
'' SRSS  - SOLID ROCKET BOOSTER SEPARATION SEQUENCER                    115
'' SSIP  - SYSTEM SOFTWARE INTERFACE PROCESSOR                          307
'' ST1G  - ASCENT FIRST STAGE GUIDANCE                                    6
'' ST2G  - ASCENT SECOND STAGE GUIDANCE                                   7
'' STVP  - SRB THRUST VECTOR CONTROL COMMAND SOP                         62
'' THCP  - TRANSLATION HAND CONTROLLER SOP                               54
'' USIF  - USER INTERFACE                                               334
'' VNTS  - VENT DOOR CONTROL SEQUENCER                                  161
''
''
''**** JOBS ***************************************************************
''
''     FIVE JOBS ARE INCLUDED IN THE MODEL. JOB 1 IS RESERVED FOR THE
''     SIMULATION EXECUTIVE  JOBS 2 THROUGH 5 ENCOMPASS ALL FUNCTIONS
''     OF THE ONBOARD DATA PROCESSING SYSTEM
''         JOB 2 - GN&C GENERAL PROCESSING
''         JOB 3 - GN&C SOPS, MONITORING, AND CHECKING
''         JOB 4 - GN&C SEQUENCING, INTERFACES, AND FDI PROCESSES
''         JOB 5 - SYSTEM CONTROL AND USER INTERFACE.
''
''  JOB      TASK     PRIORITY    NATURE   GO/NOGO   PREDECESSORS
''                  RELATV ABSOL (CYCLIC)  VARIABLE
''
''          ST1G             32
 1   2        6      10            2        401
''
''          ST2G             33
 1   2        7      10            2        401
''
''          OING             34
 1   2        8      10            2        401
''
''          ASNV             38
 1   2       15      14            2        401
```

```
''
''          AUPP                40
 1   2        19      15             2        401
''
''          ADAP                166
 1   2        36      44             2        401
''
''          IMUP                NA
''  2        38       0             2        401
''
''          ORGP                134
 1   3        40      38             2        401
''
''          SRGP                136
 1   3        41      39             2        401
''
''          AASP                100
 1   3        42      26             2        401
''
''          RASP                52
 1   3        45      19             2        401
''
''          BFFP                50
 1   3        49      18             2        401
''
''          AEAP                128
 1   3        50      36             2        401
''
''          HYSP                110
 1   2        52      30             2        401
''
''          THCP                67
 1   3        54      25             2        401
''
''          MTVP                140
 1   3        60      40             2        401
''
''          STVP                142
 1   3        62      41             2        401
''
''          OTVP                144
 1   3        64      41             2        401
''
''          OTFP                146
 1   3        65      42             2        401
''
''          MPSD                44
 1   4        70      17             2        401
''
''          SFIL                NA
```

```
''    4      71      0          2      401
''
''           IMRM              NA
''    4      72      0          2      401
''
''           RCSF              112
 1    4      91      31         2      401
''
''           OMSF              102
 1    4      92      27         2      401
''
''           BFFD              30
 1    4      95      8          2      401
''
''           ATTP              122
 1    2      97      34         2      401
''
''           OMQM              21
 1    3      101     4          2      401
''
''           RCQM              23
 1    3      102     5          2      401
''
''           GAXI              25
 1    4      110     6          2      401
''
''           RSLS              68
 1    4      114     25         2      401
''
''           SRSS              162
 1    4      115     44         2      401
''
''           ETSS              164
 1    4      116     44         2      401
''
''           SMEM              106
 1    3      119     28         2      401
''
''           SRBM              108
 1    3      120     29         2      401
''
''           ASNS              NA
''    4      139     0          2      401
''
''           VNTS              46
 1    4      161     17         2      401
''
''           RNGS              113
 1    4      164     32         2      401
''
```

```
''          MOPS            172
 1   2       165     46          2       401
''
''          ASAI            36
 1   2       168     12          2       401
''
''          RHCP            62
 1   3       171     23          2       401
''
''          GCSI            124
 1   4       175     35          2       401
''
''          ASDP            150
 1   2       176     42          2       401
''
''          GSWP            60
 1   2       180     21          2       401
''
''          SMEP            170
 1   3       181     45          2       401
''
''          OMFS            152
 1   4       182     43          2       401
''
''          OMIC            48
 1   4       183     17          2       408
''
''          OASC            114
''   3       187     32          2       401
''
''          SRSC            118
 1   3       188     32          2       401
''
''          ARCP            116
 1   3       190     32          2       401
''
''          EDFP            115
 1   3       193     32          2       401
''
''          AUPS            12
 1   2       197      2          2       401
''
''          IDAP            130
 1   2       201     37          2       401
''
''          SRDA            120
 1   2       203     33          2       401
''
''          ADIP            6
 1   2       206      0          2       401
```

```
''
''          AMDP              8
 1   2       210       0              2        401
''
''          GEFC              178
 1   2       306       48             2        401
''
''          SSIP              180
 1   5       307       49             2        401
''
''          GMIN              176
 1   2       309       47             2        401
''
''          IMMC              31
 1   2       319        9             2        401
''
''          MCDS              35
 1   5       332       11             2        401
''
''          LDBP              65
 1   5       333       23             2        401
''
''          USIF              55
 1   5       334       19             2        401
''
''          CDIP              10
 1   5       335        1             2        401
''
''          GPSW              19
 1   5       337        3             2        401
''
''
''**** TASKS ***************************************************************
''
''     TASKS 1 THROUGH 5 ARE RESERVED FOR THE SIMULATION EXECUTIVE.
''
''ASCENT FIRST STAGE GUIDANCE -ST1G  (EVENT 19 TO EVENT 28)
''EXECUTED AT 160 MS INTERVALS AT SRB IGNITION IN MM102, AND REDUCED TO
''500 MS INTERVALS AFTER TOWER CLEARANCE (EVENT 21)
''4.1     CLASS    DELAY     REQUIRED ELEMENTS
 2   6      1        0       30171  1
''
''ASCENT SECOND STAGE GUIDANCE - ST2G   (EVENT 28 TO EVENT 32)
''EXECUTED AT 2000 MS INTERVALS AT START OF MM103 UNTIL MECO CMD
''(EVENT 32)
''4.2     CLASS    DELAY     REQUIRED ELEMENTS
 2   7      1        0       30171  1
''
''ORBIT INSERTION GUIDANCE - OING (EVENT 36 TO EVENT 44, EVENT 45
''TO EVENT 49)
```

```
''EXECUTED AT 2000 MS INTERVALS DURING MM104 AND GUIDANCE PHASE OF MM105
''4.3     CLASS    DELAY     REQUIRED ELEMENTS
 2   8      1        0       30156  30171  1
''
''ASCENT NAVIGATION - ASNV
''EXECUTED AT 4000 MS INTERVALS AT START OF NAV INIT (EVENT 14) IN MM101
''THROUGH MM106
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  15     1        0       30215  30013  1
''
''ASCENT USER PARAM PROCESSING - AUPP
''EXECUTED AT 2000 MS INTERVALS FROM EVENT 14 IN MM101, THEN
''EXECUTED AT 160 MS INTERVALS IN MM102 FROM SRB IGNITION CMD (EVENT 19)
''TO TOWER CLEAR (EVENT 21), AT 500 MS INTERV FROM TOWER CLEAR TO SRB
''SEP CMD (EVENT 28), AT 2000 MS INTERVALS IN MM103 FROM SRB SEP TO
''V GR/EQ Y (EVENT 31), AT 500 MS INTERV FROM V GR/EQ Y TO MECO CMD
''(EVENT 32), AT 2000 MS INTERV IN MM104, MM105, AND MM106, EXCEPT NO
''PROC DURING MODE TRANSITION FROM MM104 TO MM105 WHEN GUID INIT
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  19     1        0       30212  1
''
''AERO-JET DIGITAL AUTOPILOT - ADAP
''EXECUTED AT 40 MS INTERVALS IN MM103 FROM MECO CMD (EVENT 32) TO
''ET SEP CMD (EVENT 34).
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  36     1        0       30204  30207  30219  1
''
''IMU INERTIAL PROCESSING - IMUP
''*** ASSUME ACCURATE REPRESENTATION BY 20309 AND 20319
''        CLASS    DELAY     REQUIRED ELEMENTS
''  38
''
''ORBITER RATE GYRO SOP - ORGP
''EXECUTED AT 40 MS INTERVALS DURING MM101 THRU MM106
'         CLASS    DELAY     REQUIRED ELEMENTS
 2  40     1        0       30159  30011  50022  50023  1
''
''SOLID ROCKET BOOSTER RATE GYRO SOP - SRGP
''EXECUTED AT 40 MS INTERVALS DURING MM101 & MM102
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  41     1        0       30159  30011  50022  50023  1
''
''ACCELEROMETER ASSEMBLY SOP - AASP
''EXECUTED AT 40 MS INTERVALS DURING MM101 AND MM102
''        CLASS    DELAY     REQUIRED ELEMENTS
 2  42     1        0       30159  30011  50006  50007  1
''
''RADAR ALTIMETER SOP - RASP
''EXECUTED AT 160 MS INTERVALS FROM ET SEPCMD (EVENT 34) IN MM103 TO
''TRANSITION TO MM104 (EVENT 36)
```

```
''          CLASS    DELAY     REQUIRED ELEMENTS
 2  45       1        0         30306  30011  50008  50009  1
''
''BODYFLAP POSITION FEEDBACK SOP - BFFP
''EXECUTED AT 160 MS INTERV DURING MM101 THRU MM104 UNTIL MPS DUMP
''COMPLETE (EVENT 43A)
''          CLASS    DELAY     REQUIRED ELEMENTS
 2  49       1        0         30159  30011  50046  50047  1
''
''AEROSURFACE ACTUATOR CMD SOP - AEAP
''EXECUTED AT 40 MS INTERVALS DURING MM101 THRU MM104 UNTIL MPS DUMP
''COMPLETE (EVENT 43A).
''          CLASS    DELAY     REQUIRED ELEMENTS
 2  50       1        0         30163  50053  1
''
''HYDRAULIC SYSTEM SOP - HYSP (EVENT 4 TO EVENT 43A)
''EXECUTED AT 40 MS INTERVALS FROM APUS ON AND SLEW CHECK CMD
''IN MM101 UNTIL MPS DUMP COMPLETE IN MM104.
''          CLASS    DELAY     REQUIRED ELEMENTS
 2  52       1        0         30159  50022  50023  1
''
''TRANSLATION HANDCONTROLLER SOP - THCP
''EXECUTED AT 80 MS INTERVALS STARTING AT MECO (EVENT 33) IN MM103 THRU
''MM106
''          CLASS    DELAY     REQUIRED ELEMENTS
 2  54       1        0         30159  1
''
''MPS THRUST VECTOR CONTROL COMMAND SOP - MTVP
''EXECUTED AT 40 MS INTERVALS DURING MM101 THRU MM104
''UNTIL MPS DUMP COMPLETE (EVENT 43A)
''          CLASS    DELAY     REQUIRED ELEMENTS
 2  60       1        0         30162  50064  50065  50066  50067  1
''
''SRB THRUST VECTOR CONTROL COMMAND SOP - STVP
''EXECUTED AT 40 MS INTERVALS DURING MM101 & MM102
''          CLASS    DELAY     REQUIRED ELEMENTS
 2  62       1        0         30162  50064  50065  50066  50067  1
''
''OMS THRUST VECTOR CONTROL COMMAND SOP - OTVP
''EXECUTED AT 40 MS INTERVALS FROM MECO (EVENT 33) IN MM103 TO OMS
''CUTOFF (EVENT 42A) IN MM104 AND FROM GUIDANCE INIT (EVENT 45) TO OMS
''CUTOFF (EVENT 48A) IN MM105.
''          CLASS    DELAY     REQUIRED ELEMENTS
 2  64       1        0         30162  50064  50065  50066  50067  1
''
''OMS TVC FEEDBACK SOP - OTFP
''EXECUTED AT 40 MS INTERVALS FROM MECO (EVENT 33) IN MM103 TO OMS
''CUTOFF (EVENT 42A) IN MM104 AND FROM GUIDANCE INIT (EVENT 45) TO
''OMS CUTOFF (EVENT 48A) IN MM105
''          CLASS    DELAY     REQUIRED ELEMENTS
```

```
 2  65      1        0       30159  50040  50041  1
''
''MPS DUMP SEQUENCER - MPSD (EVENT 33A TO EVENT 43A)
''EXECUTED AT 160 MS INTERVALS AFTER MECO+ X SEC IN MM103 UNTIL MPS
''DUMP COMPLETED IN MM104
''         CLASS    DELAY     REQUIRED ELEMENTS
 2  70      1        0       30177  50022  50023  50064  50065  50066 *
                             50073  1
''
''SELECTION FILTERING - SFIL
''***REPRESENTED AS ROUTINE 30011
''         CLASS    DELAY     REQUIRED ELEMENTS
''  71
''
''IMU REDUNDANCY MANAGEMENT - IMRM
''***REPRESENTED AS ROUTINE 30166
''         CLASS    DELAY     REQUIRED ELEMENTS
''  72
''
''REACTION CONTROL SYSTEM FDI - RCSF
''EXECUTED AT 40 MS INTERVALS
''***ASSUME WRITE TO CLOSE VALVES ONLY IF FAULT INDICATED (LEAK OR
''   RUNAWAY THRUSTER)
''         CLASS    DELAY     REQUIRED ELEMENTS
 2  91      1        0       30214  50006  50007  50022  50023  50038 *
                             50039  50046  50047  50064  50065  50066 *
                             50067  50079  50080  50081  50082  1
''
''ORBITAL MANEUVERING SYSTEM FDI - OMSF
''EXECUTED AT 40 MS INTERVALS FROM OMS IGNITION CMD IN MM101
''(EVENT 37) THRU REMAINDER OF MM104 (EVENT 44) AND FROM OMS
''IGNITION CMD IN MM105 (EVENT 46) THRU REMAINDER OF MM105 (EVENT 49)
''         CLASS    DELAY     REQUIRED ELEMENTS
 2  92      1        0       30214  1
''
''BODY FLAP COMMAND FDIR - BFFD (EVENT 1 TO EVENT 43A)
''EXECUTED AT 320 MS INTERVALS DURING MM101 THRU MM104, UNTIL MPS
''DUMP COMPLETE.
''         CLASS    DELAY     REQUIRED ELEMENTS
 2  95      1        0       30213  1
''
''ATTITUDE PROCESSING - ATTP
''EXECUTED AT 40 MS INTERVALS P.QUATERNION AT NAV INITIATION (EVENT 14)
''IN ALL MM
''         CLASS    DELAY     REQUIRED ELEMENTS
 2  97      1        0       30210  1
''
''ORBITER MANEUVERING SYSTEM QUANTITY MONITOR - OMQM
''EXECUTED AT 1000 MS INTERVALS
''         CLASS    DELAY     REQUIRED ELEMENTS
```

```
 2 101      1        0        30159  50046  50047  50024  50025  50026 *
                              50027  1
''
''REACTION CONTROL SYSTEM QUANTITY MONITOR - RCQM
''EXECUTED AT 1000 MS INTERVALS
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 102      1        0        30159  50026  50027  50012  50013  50050 *
                              1
''
''GN&C ANNUNCIATION INTERFACE - GAXI
''EXECUTED AT 1000 MS INTERVALS
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 110      1        0        30159  50042  50043  50046  50047  50012 *
                              50013  50022  50023  50024  50025  50026 *
                              50027  1
''
''REDUNDANT SET LAUNCH SEQUENCE PROCESSING - RSLS
''EXECUTED AT 80 MS INTERVALS DURING MM101
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 114      1        0        30176  50024  50025  50026  50027  50064 *
                              50065  50066  50067  50069  50070  50071 *
                              50072  1
''
''SRB SEPARATION SEQUENCER - SRSS (EVENT 25 TO EVENT 28)
''EXECUTED AT 40 MS INTERVALS IN MM102 WHEN MET GR/EQ X SEC
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 115      1        0        30177  50022  50023  50069  50070  50071 *
                              50072  1
''
''EXTERNAL TANK SEPARATION SEQUENCER - ETSS (EVENT 33 TO EVENT 36)
''EXECUTED AT 40 MS INTERVALS IN MM103 AFTER MECO
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 116      1        0        30177  50042  50043  50069  50070  50071 *
                              50072  50084  50085  1
''
''SS MAIN ENGINE MONITOR FUNCTION - SMEM (EVENT 4 TO EVENT 43A)
''EXECUTED AT 40 MS INTERVALS FROM APUS ON AND SLEW CHECK CMD
''IN MM101 UNTIL MPS DUMP COMPLETE IN MM104.
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 119      1        0        30159  50046  50047  1
''
''SRB MONITOR FUNCTION - SRBM (EVENT 1 TO EVENT 28)
''EXECUTED AT 40 MS INTERVALS DURING MM101 AND MM102
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 120      1        0        30159  30011  50022  50023  50046  50047 *
                              1
''
''ASCENT NAVIGATION SEQUENCER - ASNS
''***REPRESENTED AS ROUTINE 30013
''         CLASS    DELAY     REQUIRED ELEMENTS
```

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'' 139
''
''VENT DOOR CONTROL SEQUENCER - VNTS
''EXECUTED AT 160 MS INTERVALS WHEN TBO = -6.1 SEC (EVENT 13)
''UNTIL DOORS CLOSE, AND WHEN MET GR/EQ 10 SEC (EVENT 22) UNTIL
''DOORS OPEN
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 161      1        0       30177  50064  50065  50066  50067  50079 *
                             50080  50081  50082  1
''
''RANGE SAFETY - RNGS
''EXECUTED AT 40 MS INTERVALS WHEN MET GR/EQ X SEC (EVENT 24)
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 164      1        0       30177  50069  50070  50071  50072  1
''
''SSME OPERATIONS - MOPS (EVENT 19 TO EVENT 34)
''EXECUTED AT 40 MS INTERVALS IN MM102 AND MM103 UNTIL ET SEP CMD
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 165      1        0       30216  50046  50047  50064  50065  50066 *
                             1
''
''ASCENT ATTITUDE DIRECTOR INDICATOR PROCESSOR - ASAI
''EXECUTED AT 160 MS INTERVALS FOR PROCESSING AND AT 960 MS INTERVALS
''FOR SWITCHES STARTING AT NAV INITIATION (EVENT 14)
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 168      1        0       30304  50054  1
''
''THREE AXIS RHC SOP - RHCP
''EXECUTED AT 80 MS INTERVALS STARTING AT ET SEPARATION (EVENT 34)
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 171      1        0       30211  30011  50038  50039  1
''
''GUIDANCE/CONTROL STEERING INTERFACE - GCSI (EVENT 19 TO EVENT 50)
''EXECUTED AT 40 MS INTERVALS IN MM102 THRU MM106
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 175      1        0       30206  1
''
''ASCENT DIGITAL AUTOPILOT - ASDP
''EXECUTED AT 40 MS INTERVALS AFTER ORB/FCS VERIF (EVENT 5) IN MM101
''UNTIL MECO (EVENT 33) IN MM103
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 176      1        0       30183  30207  30204  30202  30203  1
''
''GN&C SWITCH PROCESSOR - GSWP
''EXECUTED AT 80 MS INTERVALS DURING ALL MAJOR MODES
''*** ASSUME FF DISCRETES CORRESPOND TO SWITCHES AND PANEL SWITCHES
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 180      1        0       30159  50006  50007  50038  50039  1
''
''SS MAIN ENGINE SOP - SMEP
```

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''EXECUTED AT 40 MS INTERVALS UNTIL MPS DUMP COMPLETE (EVENT 43A) IN
''MM104
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 181       1        0       30181  30220  50034  50035  50061  50062 *
                             50050  50063  1
''
''OMS FIRING SEQUENCER - OMFS
''EXECUTED AT 40 MS INTERVALS FROM OMS IGNITION (EVENT 37) TO OMS CUTOFF
''(EVENT 42A) IN MM104
''EXECUTED AT 40 MS INTERVALS FROM OMS IGNITION (EVENT 46) TO OMS CUTOFF
''(EVENT 48A) IN MM105
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 182       1        0       30185  50053  1
''
''OMS-TO-OMS INTERCONNECT - OMIC
''EXECUTED AT 160 MS INTERVALS WHEN OMS ENGINE FAILURE IN -
''MM104 (EVENT 40A/B TO EVENT 42A),
''MM105 (EVENT 46A/B TO EVENT 48A)
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 183       1        0       30186  50053  50046  50047  1
''
''ORB ACTUATOR SLEW CHECK - OASC (EVENT 4 TO EVENT 5)
''EXECUTED AT 40 MS INTERVALS DURING ORB/FCS VERIF IN MM101
''         CLASS    DELAY     REQUIRED ELEMENTS
'' 187
''
''SRB ACTUATOR SLEW CHECK - SRSC (EVENT 8 TO EVENT 8A)
''EXECUTED AT 40 MS INTERVALS DURING SRB/FCS VERIF IN MM101
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 188       1        0       30188  1
''
''ASCENT RCS COMMAND SOP - ARCP
''EXECUTED AT 40 MS INTERVALS STARTING AT FCS TVC RETRIM (EVENT 32)
''IN MM103 THRU MM106
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 190       1        0       30218  50064  50065  50066  50067  50079 *
                             50080  50081  50082  1
''
''ELEVON DELTA PRESSURE FEEDBACK SOP - EDFP (EVENT 19 TO EVENT 28)
''EXECUTED AT 40 MS INTERVALS DURING MM102
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 193       1        0       30159  30011  50046  50047  1
''
''ASCENT/USER PARAM PROCESSING SEQUENCER - AUPS
''EXECUTED AT 2000 MS INTERVALS STARTING AT NAV INITIATION (EVENT 14)
''IN MM101 THRU MM106
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 197       1        0       30014  1
''
''INSERTION DIGITAL AUTOPILOT - IDAP
```

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''EXECUTED AT 40 MS INTERVALS STARTING AT ET SEP (EVENT 34) IN MM103
''THRU MM106.
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 201       1        0       30204  30183  30203  30170  1
''
''SRB DATA ACQUISITION - SRDA (EVENT 1 TO EVENT 28)
''EXECUTED AT 40 MS INTERVALS IN MM101 AND MM102
''DATA FOR DOWNLIST
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 203       1        0       30159  50044  50045  1
''
''ASCENT DISPLAY PROCESSING - ADIP (EVENT 1 TO EVENT 36)
''EXECUTED AT 2000 MS INTERVALS IN MM101, MM102, AND MM103 TO EVENT 31
''(MECO MON), THEN AT 500 MS INTERVALS TO END OF MM103.
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 206       1        0       30221  1
''
''ASCENT MANEUVER DISPLAY PROCESSING - AMDP (EVENT 36 TO EVENT 50)
''EXECUTED AT 2000 MS INTERVALS IN MM104, MM105, AND MM106
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 210       1        0       30221  1
''
''FAST CYCLE EXECUTIVE - GEFC
''EXECUTED AT 40 MS INTERVALS
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 306       1        0       30301  50010  50020  50021  50052  50011 *
                              1
''SYSTEM SOFTWARE INTERFACE PROCESSOR - SSIP
''EXECUTED AT 40 MS INTERVALS
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 307       1        0       30116  50028  50029  50058  1
''
''MINOR CYCLE EXECUTIVE - GMIN
''EXECUTED AT 40 MS INTERVALS
''NOTE IMU REFERENCE UPDATE AT EVENT 11
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 309       1        0       30045  30303  30166  1
''
''IMU MAJOR CYCLE EXECUTIVE - IMMC
''EXECUTED AT 320 MS INTERVALS
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 319       1        0       30309  30305  30166  1
''
''MCDS INPUT PROCESSOR - MCDS
''EXECUTED AT 200 MS INTERVALS
''         CLASS    DELAY     REQUIRED ELEMENTS
 2 332       1        0       30148  30149  1
''
''LDB I/O PROCESSOR - LDBP
''EXECUTED AT 40 MS INTERVALS DURING MM101
```

```
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 333      1        0       30136  30149         1
''
''USER INTERFACE CONTROL - USIF
''EXECUTED ON DEMAND
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 334      1        0       30313  50059  50060  1
''
''CYCLIC DISPLAY PROCESSING - CDIP
''EXECUTED AT 100 MS INTERVALS
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 335      1        0       30314  50055  50056  50057  1
''
''GPC SWITCH MONITOR - GPSW
''EXECUTED AT 1000 MS INTERVALS
''        CLASS    DELAY     REQUIRED ELEMENTS
 2 337      5        0       30159  1
''
''
''
''**** ROUTINES ************************************************************
''
''     EACH FUNCTION OR SET OF FUNCTIONS CALLED IN PERFORMANCE OF A
''     SCHEDULED TASK IS DEFINED AS A ROUTINE.  ROUTINE 1 IS RESERVED
''     FOR THE SIMULATION EXECUTIVE.  ROUTINES WITH NUMBERS GREATER
''     THAN 200 REPRESENT SETS OF FUNCTIONS
''
''SELECTION FILTERING   (TASKS 40, 41, 42, 45, 49, 171, 193, 120)
''*** REPLACES 20071
''   SF
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP TIME
 3  11   1    110001        1      0    10    444   441 0 0
''
''ASCENT NAVIGATION SEQUENCER FUNCTIONS   (TASK 15)
''   AS_NAV_SEQ
''   ASC_NAV_INIT     ASCENT NAVIGATION INITIATION
''     SHARE  LIB DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3  13   1    110001        1      0    10    444   325 0 0
''
''ASCENT/USER PARAMETER PROCESSING SEQUENCE (TASK 197)
''   ASC_UPP_SEQ
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP TIME
 3  14   1    110001        1      0    10    444   326 0 0
''
''IMU PROCESSING   (TASK 309)
''   GMA_MIN_EXEC          IMU MINOR CYCLE EXECUTIVE
''   GMD_RES_PROC          IMU RESOLVER PROCESSOR
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP TIME
 3  45   1    110001        1      0    10    444   356 0 0
''
```

```
''SYSTEM SOFTWARE INTERFACE   (TASK 307)
''   AIE_SIP                  SYSTEM INTERFACE PROCESSOR
''   DCD_DOWNLIST             GPC DOWNLIST FORMATTER
''   DIM_ICC_COLLECTOR        ICC MESSAGE COLLECTOR
''   DME_ICC_ROUT             ICC MESSAGE ROUTER
''   DMS_FMS                  FAULT MESSAGE SCAN
''      SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 116   0    110001      800      0    10    444   430 0.216 10
''
''LDB PROCESSING   (TASK 333)
''   DGI_LDB_IO               LDB I/O PROCESSOR
''   DLM_LDB_ROUT             LDB MESSAGE ROUTER
''      SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 136   1    110001     3040      0    10    444   16 0.384 0
''
''MCDS INPUT PROCESSOR   (TASK 332)
''   DMI_MCDS_IN
''      SHARE  LIB DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 148   0    110001      400      0    10    444   16 0.18 0
''
''MCDS MESSAGE PROCESSOR  (TASKS 332, 333)
''   DMM_MCDS_PROCESS
''      SHARE  LIB DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 149   1    110001     2200      0    10    444   432  0  0
''
''MANEUVER TRIM DISPLAY SUPPORT (TASK 8)
''      SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 156   1    110001        1      0    10    444    16 0.6 0
''
''DATA ACQUISITION, MONITORING AND FEEDBACK
''   ORB_RG_SOP                                              (TASK  40)
''   SRB_RG_SOP                                              (TASK  41)
''   AA_SOP                                                  (TASK  42)
''   ARA_GPC_SWITCH                                          (TASK 337)
''   BF_PFB_SOP                                              (TASK  49)
''   OMS_TVC_FB_SOP                                          (TASK  65)
''   OMS_QTY_MON                                             (TASK 101)
''   RCS_QTY_MON                                             (TASK 102)
''   GAX                                                     (TASK 110)
''   GN&C_SW_PROC                                            (TASK 180)
''   HYDR_SYS_SOP                                            (TASK  52)
''   THC_SOP                                                 (TASK  54)
''   SRB_DATA_ACQ                                            (TASK 203)
''   SSME_MON_FCN                                            (TASK 119)
''   SRB_MON_FCN                                             (TASK 120)
''      SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 159   1    110001        1      0    10    444   446 0 0
''
''THRUST VECTOR CONTROL CMD SOP   (TASKS 60, 62, 64)
''   MPS_TVC_CMD_SOP     (TASK 60)
```

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''   SRB_TVC_CMD_SOP      (TASK 62)
''   OMS_TVC_CMD_SOP      (TASK 64)
''     SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 162   1    110001        1      0    10     444    346 0 0
''
''AEROSURFACE ACTUATOR CMD SOP    (TASK 50)
''   AERO_ACT_SOP
''     SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 163   1    110001        1      0    10     444    337 0 615 0
''
''IMU REDUNDANCY MGMT    (TASKS 309, 319)
''*** REPLACES 20072
''   IMU_RM
''     SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 166   1    110001        1      0    10     444    16  0.14  0
''
''RCS COMMAND GENERATION    (TASK 201)
''   RCS_CG
''     SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 170   1    110001        1      0    10     444    327 0 0
''
''COMPUTE STEERING CMDS    (TASKS 6, 7, 8)
''   AS_1STG_GUID    (TASK 6)
''   AS_2STG_GUID    (TASK 7)
''   ORB_INS_GUID    (TASK 8)
''     SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 171   1    110001        1      0    10     444    328 0 0
''
''REDUNDANT SET LAUNCH PROCESSING SEQUENCE    (TASK 114)
''   R/S_LCH_SEQ    (REF. OFT 12, 4.1 1)
''     SHARE  LIB DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 176   1    110001        1      0    10     444    341  0  0
''
''SEQUENCERS
''   SRB_SEP_SEQ       SRB SEPARATION                          (TASK 115)
''   ET_SEP_SEQ        EXTERNAL TANK SEPARATION                (TASK 116)
''   MPS_DUMP          MAIN PROPULSION SYSTEM DUMP             (TASK  70)
''   RNG_SAFETY        RANGE SAFETY FUNCTION                   (TASK 164)
''   VENT_CNTL_SEQ     VENT DOOR CONTROL                       (TASK 161)
''     SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 177   1    110001        1      0    10     444    340 0 0
''
''MAIN ENGINE SOP    (TASK 181)
''   SSME_SOP
''     SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 181   1    110001        1      0    10     444    16 0.23 0
''
''FLIGHT CONTROL RECONFIGURATION    (TASKS 176, 201)
''   FC_RECON    (REF. OFT 5, 4.6.3)
''     INITIALIZATION
```

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''      ANNUNCIATION
''      SUBPHASE_AND_MODING_INDICATORS
''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 183   1     110001        1      0     10     444    329 0 0
''
''ORBITAL MANEUVERING SYSTEM FIRING SEQUENCE   (TASK 182)
''   OMS_FIRE_SEQ   (REF. OFT 12, 4 7.6)
''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 185   1     110001        1      0     10     444    342  0  0
''
''OMS TO OMS INTERCONNECT FUNCTION   (TASK 183)
''   OMS/OMS_CONN
''      SHARE  LIB DS      SIZE   TIME  PROCSR  MEMORY  COMP TIME
 3 186   1     110001        1      0     10     444    16 0 279 0
''
''SOLID ROCKET BOOSTER ACTUATOR SLEW CHECK   (TASK 188)
''   SRB_SLEW
''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 188   1     110001        1      0     10     444    16 0 384 0
''
''COMMAND PROCESSING  (TASK 176)
''   CMD_PROC_SRB   SOLID ROCKET BOOSTER  (REF  OFT 5, 4 6.4.4)
''     TRIM_MIX_SRB     TRIM MIXING LOGIC COMPUTATION            40 MS
''     BIAS_LIM_SRB_PREP CHAMBER PRESSURE PARAM CALCULATIONS     80 MS
''     BIAS_LIM_SRB     THRUST VECTOR DEFL. & ACTUATOR STROKE LIM40 MS
''     SRB_LIM_SUBRO    THRUST VECTOR DEFL & ACT STR.LIMITING CAL
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP TIME
''   CMD_PROC_ORB   ORBITER  (REF. OFT 5, 4.6.4.3)
''     TRIM_MIX_ORB     TRIM MIX NOZZLE DEFLECTION COMP          40 MS
''     BIAS_LIM_ORB     BIAS COMP, STROKE & RATE LIMITS          40 MS
''     PRL_ORB          PRIORITY RATE LIMITATION CALC FOR STROKE 40 MS
''     PRL_ORB_SUBRO    ACTUATOR COMMANDS COMP. 3X FOR EACH SSME
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 202   1     110001        1      0     10     444    330  0  0
''
''THRUST VECTOR CONTROL LAWS  (TASKS 176, 201)
''   TVC_ORB_SRB   (REF. OFT 5, 4 6.4 2)
''     CMD_ROLL         ROLL THRUST VECTOR DEFL  COMMANDS COMP.
''     CMD_PITCH        PITCH THRUST VECTOR DEFL. COMMANDS COMP
''     FB_S1C_PITCH     STAGE 1 PITCH RATE FEEDBACK ERROR COMP.
''     FB_S2C_PITCH     STAGE 2 PITCH RATE FEEDBACK ERROR COMP.
''     CMD_YAW          YAW THRUST VECTOR DEFLECTION COMP
''     FB_S1C_YAW       STAGE 1 YAW RATE FEEDBACK ERROR COMP
''     FB_S2C_YAW       STAGE 2 YAW RATE FEEDBACK ERROR COMP
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP TIME
 3 203   1     110001        1      0     10     444    331 0 0
''
''LINEAR INTERPOLATION FUNCTIONS (TASKS 36, 176, 201)
''   INTERPS   (REF. OFT 5, 4.6 4 5)                          160 MS
''     VREL_XTRAP       RELATIVE VELOCITY EXTRAPOLATION CALC
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''      S1T_TRIMS_ACC     STAGE 1 TRIMS & ACCELERATION CALC
''      S2T_TRIMS         STAGE 2 TRIMS CALC
''      ELEV_SCHED        SCHEDULED ELEVON DEFLECTION COMP
''      TVC_GAINS         THRUST VECTOR CONTROL GAINS CALC
''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 204   1    110001         1      0    10     444    332  0  0
''
''GUIDANCE & CONTROL STEERING INTERFACE   (TASK 175)
''   GC_INTERF    (REF. OFT 5, 4.6.4 1)                          INTERVAL
''      DBCMDS_S2G        THRUST DIRECTION & BODY ROTAT.RATE COMP 480 MS
''      DBACCEL           ACCELLERATION & RATE LIMITING CALC      480 MS
''      DBQUAT            QUATERNION INTEGRATION CALC              40 MS
''      ATTERS            ATTITUDE ERRORS COMP                     40 MS
''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 206   1    110001         1      0    10     444    440 0 0
''
''AEROSURFACE CONTROL FUNCTIONS   (TASKS 36, 176)
''   AEROSRF_CNTRL   (REF. OFT 5, 4.6.4.6)                        INTERVAL
''      BF_HYSTER           BODY FLAP DEADBAND/HYSTERESIS COMP   160 MS
''      ELVN_LD_REL         ELEVON LOAD RELIEF CALC               80 MS
''      ELVN_LD_REL_SUBRO   ELEVON LOAD RELIEF SUBROUTINE 2X      80 MS
''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP TIME
 3 207   1    110001         1      0    10     444    333 0 0
''
''ATTITUDE PROCESSING FUNCTIONS  (TASK 97)
''   ATT_PROC   (REF  OFT 5, 4 6.5)                               INTERVAL
''      ATT_PROC_INIT     ATTITUDE PROCESSING INITIALIZATION       INIT
''      ATT_PROC_MODE_CHG ATTITUDE MODE CHANGE                     INIT
''      ATT_PROC_OUTER    OUTER LOOP PRECISION                     960 MS
''      ATT_PROC_INNER    INNER LOOP QUATERNION UPDATE              40 MS
''      ATT_PROC_ENTRY    ENTRY THRU LANDING ATTITUDE               NA
''      ATT_PROC_DISP     ATTITUDE DISPLAY                          40 MS
''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 210   1    110001         1      0    10     444    343  0  0
''
''ROTATIONAL HAND CONTROLLER PROCESSING FUNCTIONS  (TASK 171)
''   3-AX_RHC_SOP   (REF. OFT 10, 4.171)
''      RHC_SOP_INIT      RHC SUBSYSTEM OPS PROG INITIATION
''      RHC_COMP          RHC COMPENSATION CALCULATIONS
''      RHC_DB            RHC DEADBANDING COMPUTATION
''      RHC_STA_SEL       RHC STATION SELECT CALC.
''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 211   1    110001         1      0    10     444     16  0.2  0
''
''ASCENT USER PARAMETER PROCESSING   (TASK 19)
''   ASC_UPP
''   ASC_UPP_INIT      USER PARAM PROCESSING INITIATION
''   ASC_Q_BAR_INIT    DYNAMIC PRESSURE CALCULATIONS
''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 212   1    110001         1      0    10     444    334 0 0
```

```
''
''BODY FLAP COMMAND FDIR (TASK 95)
''   BF_CMD_FDIR
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 213   1    110001        1      0    10    444    16 0 04 0
''
''FAULT DETECTION AND ISOLATION   (TASKS 91, 92)
''   OMS_FDI                                                (TASK  92)
''   RCS_FDI                                                (TASK  91)
''      AVAIL_JET_STAT   AVAILABLE JET STATUS COMPUTATIONS
''      JET_FAIL_OFF     JET FAILURE MONITOR CALC
''      JET_FAIL_ON      JET FAILURE MONITOR CALC #2
''      JET_LEAK         JET LEAKAGE MONITOR CALC
''      MANIF_STAT       MANIFOLD STATUS MONITOR CALC
''      JET_FAULT_LIM    JET FAULT LIMIT CALC
''     SHARE  LIB DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 214   1    110001        1      0    10    444   344  0  0
''
''ASCENT NAVIGATION   (TASK 15)
''   ASC_NAV
''     SNAP_IMU
''     NAV_STATE_PROP         NAV STATE PROPAGATION
''     COVEXTRAP_PF           COVARIANCE MATRIX PROPAGATION
''     MAN_ST_COV_SETUP       MANUAL STATE & COVARIANCE SETUP
''     THREE_TO_ONE_STATE
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP TIME
 3 215   1    110001        1      0    10    444   335 0 0
''
''MAIN ENGINE OPERATIONS   (TASK 165)
''   SSME_OPS
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 216   1    110001        1      0    10    444   336 0 0
''
''ASCENT REACTION CONTROL SYSTEM PROCESSING  (TASK 190)
''   AS_RCS_CMD_SOP   (REF. OFT 11, 4 190)
''     RCS_CMD_GEN          RCS COMMAND GENERATION PROC
''     RCS_INH_FIR          RCS INHIBIT THRUSTER FIRING PROC
''     SHARE  LIB.DS     SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 218   1    110001        1      0    10    444   345 0 0
''
''AERO-JET DIGITAL AUTOPILOT   (TASK 36)
''   AERO-JET-DAP                                  INTERVAL
''     AERO_RECON       RECONFIGURATION             80 MS
''     PRL              PRIORITY RATE LIMITING      40 MS
''     JSL              JET SELECTION               NA
''     BK_CHNL          BANK CHANNEL                40 MS
''     P_CHNL           PITCH CHANNEL               40 MS
''     NW_CHNL          NOSEWHEEL CHANNEL           NA
''     SB_CHNL          SPEEDBRAKE CHANNEL          NA
''     BF_CHNL          BODY FLAP CHANNEL           NA
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''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 219    1    110001         1      0    10     444  405 2.34 0.29
''
''THROTTLE CONTROL FUNCTIONS   (TASK 181)
''   THROT_XTRAP       FIRST ORDER EXTRAP IN S2G
''     (REF. OFT 5, 4.6.4 7)                                        80 MS
''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP TIME
 3 220    1    110001         1      0    10     444   449 0 0
''
''GN&C DISPLAY PROCESSING   (TASKS 206, 210)
''   ASC_DIP         ASCENT                                       (TASK 206)
''   ASC_MNVR_DIP    ASCENT MANEUVER                              (TASK 210)
''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 221    1    110001         1      0    10     444   448 0 0
''
''FLIGHT CONTROL   (TASK 306)
''   GEF_FC_EXEC            FAST CYCLE EXECUTIVE
''   GKF_FC_KIP             FC KEYBOARD INTERFACE PROCESSING
' OTHER PROCESSORS ARE DISTRIBUTED AMONG THE OTHER PRINCIPAL FUNCTIONS.
''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 301    1    110001         1      0    10     444   350 0.025 0
''
''IMU BITE PROCESSING, ACCELEROMETER ACCUMULATOR, & GYRO TORQUING
''(TASK 309)
''   GMB_IMU_BITE         IMU BITE PROCESSING
''   GMC_ACP_ACUM         ACCELEROMETER PROCESSING
''   GMF_GYO_TORQ         GYRO TORQUE PROCESSING
''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 303    1    110001         1      0    10     444   362 0 0
''
''DISPLAYS AND IMU MODING   (TASK 168)
''   GDA_DED_DISP_PROC    DEDICATED DISPLAY PROCESSOR
''   GDB_AVVI_AMI_PROC    DEDICATED DISPLAY, AVVI, AMI PROCESSOR
'    GDE_ADI_PROC         DEDICATED DISPLAY ADI PROCESSOR 160MS(TASK 168)
''   GDF_HSI_PROC         DEDICATED DISPLAY HSI PROCESSOR
''   GDZ_DISP_PROC        CRT DISPLAY PROCESSOR
''   GMN_IMU_MODING       IMU MODING
''   IMU_BITE_SUM         IMU BITE SUMMARY
''   GPC_AD_CALC          AIR-DATA CALCULATIONS
''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 304    1    110001         1      0    10     444   390 0 0
''
''IMU GYRO AND ACCELEROMETER FUNCTIONS   (TASK 319)
''   GMH_ACP_COMP         IMU ACCELEROMETER COMPENSATION
''   GML_ACP_TRSF         IMU ACCELEROMETER PULSE TRANSFORMATION
''   GMK_GYO_COMP         IMU GYRO COMPENSATION
''      SHARE  LIB.DS      SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 305    1    110001         1      0    10     444   16 1.344 0
''
''NAVIGATION   (TASK 45)
```

```
''   GNA_MLS_MEAS          MSBLS MEASUREMENT PROCESSING
''   GNB_TACAN_MEAS        TACAN MEASUREMENT PROCESSING
''   GNC_BARO_ALT          BARO-ALTIMETER MEASUREMENT PROCESSING
''   GND_RADAR_ALT         RADAR-ALTIMETER MEASUREMENT        (TASK 45)
''   GNE_NAV_EXEC          NAVIGATION EXECUTIVE
''   GN1_DATA_SNAP         DATA SAVING
''   GN3_MEAS_SCHDLR       MEASUREMENT SCHEDULER
''   GN7_NAV_FILTER        FILTER
''     SHARE  LIB.DS       SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 306   1    110001          1      0    10     444    368 0.15 0
''
''IMU MAJOR FUNCTIONS    (TASK 319)
''   GMG_MAJ_EXEC          MAJOR CYCLE EXECUTIVE
''   GMI_T_UPDATE          TRANSFORM UPDATE
''   GMJ_TOR_TRSF          TORQUING TRANSFORM
''   GMM_LAT_FUNC          LARGE ANGLE TORQUING
''   GMQ_LSF_FILR          LEAST SQUARES FILTER
''     SHARE  LIB DS       SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 309   1    110001          1      0    10     444    353  0  0
''
''USER INTERFACE SUPERVISOR   (TASK 334)
''   DMC_SUPER             USER INTERFACE CONTROL SUPERVISOR
''   DMC_FUNCTIONS         KEYBOARD FUNCTIONS
''   DMC_APP_INT           APPLICATION CONTROL INTERFACE
''   DMC_MCDS_CNT          MCDS DISPLAY CONTROL
''   DMC_APP_KEY_PROCESS   APPLICATION KEYS PROCESSING
''   DMC_DISPLAY           DISPLAY COORDINATION
''   DMC_NEW_DISPLAY       NEW DISPLAY PROCESSING
''   DMC_SEQ_REQ_PROC      SEQUENCE REQUEST PROCESSING
''   DIM_ICC_COLLECTOR     ICC MSG COLLECTOR
''     SHARE  LIB DS       SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 313   0    110001       10380     0    10     444    431  0  0
''
''CYCLIC DISPLAY PROCESSING   (TASK 335)
''   DCI#CYC               CYCLIC DISPLAY PROCESSING
''   DCI#CON               DATA CONVERSION
''   DCI#FMT               DATA FORMATTING
''     SHARE  LIB.DS       SIZE   TIME  PROCSR  MEMORY  COMP.TIME
 3 314   0    110001        5252     0    10     444 435 2.06 8 3
''
''
''**** MESSAGES ***************************************************
''
''     ALL DATA TRANSMISSIONS OF THE DPS ARE REPRESENTED AS MESSAGES.
''     MESSAGES 1 THROUGH 5 ARE RESERVED FOR THE SIMULATION EXECUTIVE.
''
''READ FROM FF01,2,3
''   ACCELEROMETER ASSEMBLY (FWD ACCEL)                  F*(TASK  42)
''   RCS VALVE STATUS (MCA)                                (TASK  91)
''   THC POS/NEG X/Y/Z (AFT/LH THC)                      D (TASK 180)
```

```
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5   6    0      70001    380  16  2 0     16  0 0     0      3
 5   7    0      50006  70001 361  0 0    360  0 0     0      3  0  2
''
''READ FROM FF01,2   (TASK 45)
''   RALT WORD (RADAR ALTM1,2)                                F*(TASK 45)
'    RALT WORD (RADAR ALTM1,2)                                D*(TASK 45)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5   8    0      70001    380  16  2 0     16  0 0     0      2
 5   9    0      50008  70001  16  4 0    360  0 0     0      2
''
''READ FROM FF01,2,3   (TASK 306)
''   IMU                                                      (TASK 306)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  10    0      70001    380  16  2 0     16  0 0     0      3
 5  11    0      50010  70001  16 32 0    360  0 0     0      3
''
''READ FROM FF01,3   (TASKS 102, 110)
''   RCS PROP TANK PRESSURES (OF2 DED SIG CON, DSC OF4)   -
''                                                  F*(TASKS 102, 110)
''   RCS PROP TANK TEMPS (DSC OF4, OF2 DED SIG CON)       F*(TASK 102)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  12    0      70001    357  16  4 0     16  0 0     0      2
 5  13    0      50012  70001  16 28 0    360  0 0     0      2  0  2
''                                                          ____
''READ CLOCK (MTU) FROM FF01,2,3   (TASK 306)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  20    0      70001    380  16  2 0     16  0 0     0      3
 5  21    0      50020  70001  16 18 0    360  0 0     0      3
''
''READ FROM FA01,2,3
''   HYDRAULIC SUPPLY PRESSURES (D&C PNL F08A8)           F*(TASK  52)
''   ORB RATE GYRO ASSEMBLY (RGA)                        DF*(TASK  40)
''   SRB RATE CYRO ASSEMBLY (LH/RH SRB RGA)               F*(TASK  41)
''   SRM CHAMBER PRESSURES (LH/RH SRB)                F*(TASKS 120, 115)
''   RCS PROPELLANT TEMPS (OA1,2,3 DED SIG CON)             (TASK  91)
''   MPS PROP PRESSURES (MPS)                         F*(TASKS  70, 110)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  22    0      70001    381  16  2 0     16  0 0     0      3
 5  23    0      50022  70001 363  0 0    360  0 0     0      3  0  2
''
''READ FROM FA03,4
''   OMS PBK ULLAGE PRESSURES (0A3 DED SIG CON)           F*(TASK 110)
''   OMS POD PROPELLANT AVAILABLE (OMS)                   F*(TASK 101)
''   MPS FUEL VALVE STATUS (MPS, MPS ENG3)                D (TASK 114)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  24    0      70001    358  16  6 0     16  0 0     0      2
 5  25    0      50024  70001 365  0 0    360  0 0     0      2  0  2
''
''READ FROM FA01,2
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''   OMS POD ULLAGE PRESSURES (OMS)                              F*(TASK 110)
''   OMS PBK HELIUM PRESSURES (OA1/2 DED SIG CON)                F*(TASK 110)
''   OMS PROPELLANT CROSSFEED VALVE STATUS (OMS)                 D*(TASK 101)
''   OMS ENG REGULATOR OUT PRESSURE (OMS)                        F*(TASK 110)
''   MPS FUEL VALVE STATUS (MPS, MPS ENG1/2)                     D (TASK 114)
''   MPS PROP ENGINE MANIFOLD PRESS (LOX/LH2 ENG MANF)           F*(TASK 110)
''   RCS PROP TANK PRESS (LH/RH OMS 001, DSC OL/OR 2)F*(TASKS 102,110)
''   RCS PROP TANK TEMPS (DSC OL/OR 2, LH/RH OMS 001)            F*(TASK 102)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  26   0     70001    381 379  0 0     16  0 0      0      2
 5  27   0     50026  70001 370  0 0    360  0 0      0      2  0  2
''
''ICC FOR REDUNDANT SET (GPC 2,3, & 4 COMMUNICATION WITH GPC 1)
''(TASK 307)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  28   1       383  70001  16 256 0    16  0 0      0      3
 5  29   1     70001    384  16 256 0   360  0 0      0      3
''
''READ MAIN ENGINE STATUS (SSME) FROM EIU1,2,3   (TASK 181)
''*** ASSUME ALL STATUS DATA WORDS ARE READ ON EVERY CYCLE OF TASK
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  34   0     70001    359  16  2 0     16  0 0      0      3
 5  35   0     50034  70001  16 64 0    360  0 0      0      3
''
''READ FROM FF01,2,3,4   (TASKS 91, 171, 180)
''   RCS VALVE STATUS (RJDF)                                       (TASK  91)
''   RCS PROPELLANT TEMPS (DSC OF4, OF2 DED SIG CON)               (TASK  91)
''   SWITCHES AND PANEL SWITCHES                                 D (TASK 180)
''   ROTATIONAL HAND CONTROLLER 1&2 (LH/RH RHC)                  F*(TASK 171)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  38   0     70001    380  16  2 0     16  0 0      0      4
 5  39   0     50038  70001 387  0 0    360  0 0      0      4  0  2
''
''READ MCA STATUS FROM FA01,2,3,4
''   OMS TVC (OMS)                                    F*(TASK 65)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  40   0     70001    381  16  2 0     16  0 0      0      4
 5  41   0     50040  70001 392  0 0     16  0 0      0      4
''
''READ PROPULSION SYSTEM STATUS FROM FA02,4
''   MPS FUEL VALVE STATUS (MPS, LOX FEED DISC V)                D (TASK 116)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  42   0     70001    393  16  2 0     16  0 0      0      2
 5  43   0     50042  70001 427  2 0    360  0 0      0      2
''
''READ SOLID ROCKET MOTOR STATUS FROM LL1, LL2, LR1, LR2   (TASK 203)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  44   0     70001    354  16  2 0     16  0 0      0      4
 5  45   0     50044  70001 395  0 0    360  0 0      0      4
''
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''READ FROM FA01,2,3,4
''   BODY FLAP POSITIONS (POS XDCR)                          F*(TASK  49)
''   ELEVON PRESSURE (LVON SW VLV)                           F (TASK 193)
''   RCS AFT THRUSTER STATUS (RJOD)                  D (TASKS  91, 101)
''   AFT TVC VALVE STATUS (ATVCD)                D*(TASKS 119, 120, 110)
''   OMS PROPELLANT VALVE STATUS (OMS)                       D (TASK 183)
''   OMS ENG PNEUMATIC SUPPLY PRESS (OMS)                    F*(TASK 110)
''   OMS POD HELIUM PRESS (OMS)                              F*(TASK 110)
''   ET LH2 LOW (ET)                                         D*(TASK 165)
''   MPS LOX LOW (MPS)                                       D*(TASK 165)
''   MPS LH2 VALVE STATUS (MPS)                               D (TASK 110)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  46   0     70001    381  16  2 0     16  0 0      0      4
 5  47   0     50046  70001 396  0 0    360  0 0      0      4  0  2
''
''WRITE TO FF01,3
''   RCS PROPELLANT QUANTITIES (D&C PNL 003)                 F (TASK 102)
''   MPS CHAMBER PRESSURES                                   F (TASK 181)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  50   0     70001    357  16  8 0     16  0 0      1      2
''
''WRITE IMU TO FF01,2,3   (TASK 306)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  52   0     70001    380  16  4 0     16  0 0      1      3
''
''WRITE TO FA01,2,3,4
''   ELEVON CMDS (ASA)                                       F*(TASK  50)
''   OMS PROPELLANT VALVE CMDS (OMS, OMS L/R ENG/POD)D(TASKS 182, 183)
''   MPS PROPELLANT VALVE CMDS (MPS/1/2/3, AFT LCA)           D (TASK  70)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  53   0     70001    381 397  0 0     16  0 0      1      4
''
''WRITE TO DDU1,2
''   ADI     ALTITUDE DIRECTOR                                (TASK 168)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  54   0     70001    382  16 22 0     16  0 0      1      2
''
''WRITE TO DEU1,2,3   (TASK 335)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  55   0     70001  60001  16 1024 0   16  0 0      1      1
 5  56   0     70001  60002  16 1024 0   16  0 0      1      1
 5  57   0     70001  60003  16 1024 0   16  0 0      1      1
''
''WRITE PRIME FRAME TO PCMMU   (TASK 307)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  58   0     70001  60095  16 512 0    16  0 0      0      1
''
''READ KEYBD 1 AND WRITE NEW DISPLAY TO DEU1   (TASK 334)
''     NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  59   0     60027  70001  434  0 0    16  0 0      0      1
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 5  60   0     50059  60001  433  0 0    16  1 0      0      1
''
''WRITE MAIN ENGINE COMMANDS TO EIU1,2,3   (TASK 181)
''*** ASSUME 1 CMD WD TO EACH EIU FOR EACH CYCLE OF TASK
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  61   0     70001  70011  16  4 0     16  0 0      1      1
 5  62   0     70001  70012  16  4 0     16  0 0      1      1
 5  63   0     70001  70013  16  4 0     16  0 0      1      1
''
''WRITE CMDS TO FA01,2,3,4
''   MPS ACTUATOR GIMBALS (ATVCD)                          F*(TASK  60)
''   MPS FUEL VALVE CMDS (MPS 1,2,3)          D (TASKS  70, 114, 165)
''   VENT PORTS                                            D (TASK 161)
''   RCS AFT THRUSTERS (RJOD)                              D (TASK 190)
''   RCS AFT PROPELLANT VALVES (RJOD)                      D (TASK  91)
''   SRB ENG ACTUATOR GIMBALS (LH/RH LT/RT SRB)            F*(TASK  62)
''   OMS ACTUATOR GIMBALS (OMS)                            F*(TASK  64)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  64   0     70001  60013 398  0 0     16  0 0      1      1
 5  65   0     70001  60014 398  0 0     16  0 0      1      1
 5  66   0     70001  60015 398  0 0     16  0 0      1      1
 5  67   0     70001  60016 398  0 0     16  0 0      1      1
''
''WRITE CMDS TO MEC1,2   (TASKS 114, 115, 116, 164)
''   SRB IGNITION ARM AND FIRE                             D*(TASK 114)
''   SRB PICS ARM AND PICS FIRE                            D*(TASK 115)
''   ORB/ET PWR DISCONNECT, PICS ARM AND PICS FIRE          *(TASK 116)
''   SAFE AND PWR OFF                                      *(TASK 164)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  69   0     70001    424 437  0 0     16  0 0      1      2
 5  70   0     70001    424 437  0 0     16  0 0      1      2
 5  71   0     70001    424 437  0 0     16  0 0      1      2
 5  72   0     70001    424 437  0 0     16  0 0      1      2
''
''WRITE TO LA01
''   PROPELLANT ISOLATION VALVE CLOSE CMDS (AFT LCA/2)      (TASK 70)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  73   0     70001  60035  16  4 0     16  0 0      1      1
''
''WRITE CMDS TO FF01,2,3,4   (TASKS 91, 161, 190)
''   VENT PORTS                                            D (TASK 161)
''   RCS FWD THRUSTERS (RJDF)                              D (TASK 190)
''   RCS FWD PROPELLANT VALVES (RJDF)                      D (TASK  91)
''      NATURE  SOURCE  SINK  LENGTH      INTERVAL   START  TOTAL
 5  79   0     70001  60009 426  0 0     16  0 0      1      1
 5  80   0     70001  60010 426  0 0     16  0 0      1      1
 5  81   0     70001  60011 426  0 0     16  0 0      1      1
 5  82   0     70001  60012 426  0 0     16  0 0      1      1
''
''WRITE ET UMBILICAL CMDS TO FA02,4   (TASK 116)
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''      NATURE   SOURCE   SINK   LENGTH       INTERVAL    START   TOTAL
 5  84    0       70001   60014  389  0 0     16  0 0       0       1
 5  85    0       70001   60016  389  0 0     16  0 0       0       1

''
''
''**** DEVICES ***********************************************************
''
''      SYSTEM COMPONENTS WHICH ARE USED AS THE ORIGIN OR TERMINUS FOR
''      DATA TRANSMISSION ARE REPRESENTED AS DEVICES.
''
''DISPLAY ELECTRONIC UNIT NO. 1
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS      SIZE            INPUT      OUTPUT    PERIOD
6   1    1       1        8192             60          31       0
''
''DISPLAY ELECTRONIC UNIT NO. 2
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''             CLASS     SIZE            INPUT      OUTPUT    PERIOD
6   2    1       1        8192             60          31       0
''
''DISPLAY ELECTRONIC UNIT NO. 3
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS      SIZE            INPUT      OUTPUT    PERIOD
6   3    1       1        8192             60          31       0
''
''DISPLAY UNIT NO. 1
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS      SIZE            INPUT      OUTPUT    PERIOD
6   5    1       1        8192             38           0       0
''
''DISPLAY UNIT NO. 2
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS      SIZE            INPUT      OUTPUT    PERIOD
6   6    1       1        8192             38           0       0
''
''DISPLAY UNIT NO  3
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS      SIZE            INPUT      OUTPUT    PERIOD
6   7    1       1        8192             38           0       0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) FF1
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS      SIZE            INPUT      OUTPUT    PERIOD
6   9    1       1        1024             60          60       0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) FF2
''       A/D  SHARE      RECORD          TRANSMISSION RATE    RESET
''            CLASS      SIZE            INPUT      OUTPUT    PERIOD
6   10   1       1        1024             60          60       0
```

```
''
''MULTIPLEXER/DEMULTIPLEXER (MDM)  FF3
''       A/D  SHARE     RECORD        TRANSMISSION RATE   RESET
''            CLASS     SIZE          INPUT      OUTPUT   PERIOD
6   11   1     1        1024             60          60     0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM)  FF4
''       A/D  SHARE     RECORD        TRANSMISSION RATE   RESET
''            CLASS     SIZE          INPUT      OUTPUT   PERIOD
6   12   1     1        1024             60          60     0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM)  FA1
''       A/D  SHARE     RECORD        TRANSMISSION RATE   RESET
''            CLASS     SIZE          INPUT      OUTPUT   PERIOD
6   13   1     1        1024             60          60     0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM)  FA2
''       A/D  SHARE     RECORD        TRANSMISSION RATE   RESET
''            CLASS     SIZE          INPUT      OUTPUT   PERIOD
6   14   1     1        1024             60          60     0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM)  FA3
''       A/D  SHARE     RECORD        TRANSMISSION RATE   RESET
''            CLASS     SIZE          INPUT      OUTPUT   PERIOD
6   15   1     1        1024             60          60     0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM)  FA4
''       A/D  SHARE     RECORD        TRANSMISSION RATE   RESET
''            CLASS     SIZE          INPUT      OUTPUT   PERIOD
6   16   1     1        1024             60          60     0
''
''DISPLAY DRIVER UNIT (DDU) NO. 1
''       A/D  SHARE     RECORD        TRANSMISSION RATE   RESET
''            CLASS     SIZE          INPUT      OUTPUT   PERIOD
6   17   1     1           0             60          60     0
''
''DISPLAY DRIVER UNIT (DDU) NO. 2
''       A/D  SHARE     RECORD        TRANSMISSION RATE   RESET
''            CLASS     SIZE          INPUT      OUTPUT   PERIOD
6   18   1     1           0             60          60     0
''
''DISPLAY DRIVER UNIT (DDU) NO. 3
''       A/D  SHARE     RECORD        TRANSMISSION RATE   RESET
''            CLASS     SIZE          INPUT      OUTPUT   PERIOD
6   19   1     1           0             60          60     0
''
''KEYBOARD UNIT (KBU) NO. 1
''       A/D  SHARE     RECORD        TRANSMISSION RATE   RESET
''            CLASS     SIZE          INPUT      OUTPUT   PERIOD
6   27   1     1           0              0           1     1
```

```
''
''KEYBOARD UNIT (KBU) NO. 2
''       A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''            CLASS     SIZE            INPUT      OUTPUT   PERIOD
6   28   1     1          0               0           1       1
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) LL1
''       A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''            CLASS     SIZE            INPUT      OUTPUT   PERIOD
6   30   1     1         1024             60          60      0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) LL2
''       A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''            CLASS     SIZE            INPUT      OUTPUT   PERIOD
6   31   1     1         1024             60          60      0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) LR1
''       A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''            CLASS     SIZE            INPUT      OUTPUT   PERIOD
6   32   1     1         1024             60          60      0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) LR2
''       A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''            CLASS     SIZE            INPUT      OUTPUT   PERIOD
6   33   1     1         1024             60          60      0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) LF1
''       A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''            CLASS     SIZE            INPUT      OUTPUT   PERIOD
6   34   1     1         1024             60          60      0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) LA1
''       A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''            CLASS     SIZE            INPUT      OUTPUT   PERIOD
6   35   1     1         1024             60          60      0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) PF1
''       A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''            CLASS     SIZE            INPUT      OUTPUT   PERIOD
6   36   1     1         1024             60          60      0
''
''MULTIPLEXER/DEMULTIPLEXER (MDM) PF2
''       A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''            CLASS     SIZE            INPUT      OUTPUT   PERIOD
6   37   1     1         1024             60          60      0
''
''PULSE CODE MODULATION MASTER UNIT (PCMMU) NO. 1
''       A/D  SHARE     RECORD          TRANSMISSION RATE   RESET
''            CLASS     SIZE            INPUT      OUTPUT   PERIOD
6   95   1     1         2048             60          60      0
```

```
''
''PULSE CODE MODULATION MASTER UNIT (PCMMU) NO. 2
''      A/D  SHARE     RECORD          TRANSMISSION RATE    RESET
''           CLASS      SIZE           INPUT      OUTPUT    PERIOD
6   96   1     1        2048             60          60      0
''
''
''**** MEMORY UNITS ***************************************************
''
''     THE GPC CORE MEMORIES ARE REPRESENTED AS MEMORY UNITS (1 - 4)
''     EACH EIU AND MEC IS REPRESENTED AS AN IMSIM MEMORY TO PERMIT
''     REDUNDANT CONCURRENT TRANSMISSIONS.
''
''THIS VARIABLE CORRECTS ROUNDING ERROR IN MEMORY TRANSM RATE
V259 = (P3*1000 + 0.5)$1
''
''MEMORY GPC 1
''        SPEED FACTOR          PAGES
7    1        1.4                212
''
''MEMORY GPC 2
''        SPEED FACTOR          PAGES
7    2        1.4                212
''
''MEMORY GPC 3
''        SPEED FACTOR          PAGES
7    3        1 4                212
''
''MEMORY GPC 4
''        SPEED FACTOR          PAGES
7    4        1.4                212
''
''ENGINE INTERFACE UNIT (EIU) 1
''        SPEED FACTOR          PAGES
 7  11        0.06                 1
''
''ENGINE INTERFACE UNIT (EIU) 2
''        SPEED FACTOR          PAGES
 7  12        0.06                 1
''
''ENGINE INTERFACE UNIT (EIU) 3
''        SPEED FACTOR          PAGES
 7  13        0.06                 1
''
''MASTER EVENTS CONTROLLER (MEC) 1
 7  14        0.06                 1
''
''MASTER EVENTS CONTROLLER (MEC) 2
 7  15        0 06                 1
''
```

```
''
''**** STORAGE UNITS ************************************************
''
''     MASS MEMORIES ARE REPRESENTED AS STORAGE UNITS.
''
''THESE MASS MEMORIES ARE NOT USED DURING ASCENT PHASE
''
''MASS MEMORY STORAGE (MM) NO. 1
''          A/D  SHARE  CYCLE  TRX RATE  CAPACITY   ACCESS PERIOD
8    1      1      1      0      125     17000000   399  500  0  0  0
''
''MASS MEMORY STORAGE (MM) NO. 2
''          A/D   SHARE  CYCLE  TRX RATE  CAPACITY   ACCESS PERIOD
8    2      1      1      0      125     17000000   399  500  0  0  0
''
''
''**** PROCESSORS ***************************************************
''
''     THE CPU OF EACH GPC IS REPRESENTED AS A PROCESSOR.
''
''CENTRAL PROCESSING UNIT (CPU) NO. 1
''       SPEED  CLASS  INTERRUPT  SWITCH  VIRT MACH  CONNECTED MEMORIES
9    1  0.48    10        5         0       1        1
''
''CENTRAL PROCESSING UNIT (CPU) NO. 2
''       SPEED  CLASS  INTERRUPT  SWITCH  VIRT MACH  CONNECTED MEMORIES
''   2  0.48    10        5         0       2        2
''
''CENTRAL PROCESSING UNIT (CPU) NO. 3
''       SPEED  CLASS  INTERRUPT  SWITCH  VIRT MACH  CONNECTED MEMORIES
''   3  0.48    10        5         0       3        3
''
''CENTRAL PROCESSING UNIT (CPU) NO. 4
''       SPEED  CLASS  INTERRUPT  SWITCH  VIRT MACH  CONNECTED MEMORIES
''   4  0.48    10        5         0       4        4
''
''
''**** DATA LINKS ***************************************************
''
''     EACH OF THE TRANSMISSION PATHS FOR DATA IN THE DDPC IS
''     REPRESENTED AS A DATA LINK.
''
''INTERCOMPUTER COMMUNICATIONS DATALINK - IC1
''          MODE   TRANSMISSION RATE     TIME LAG
10    1       0         60                  0
''
''INTERCOMPUTER COMMUNICATIONS DATALINK - IC2
''          MODE   TRANSMISSION RATE     TIME LAG
10    2       0         60                  0
''
```

```
''INTERCOMPUTER COMMUNICATIONS DATALINK - IC3
''          MODE   TRANSMISSION RATE     TIME LAG
10    3       0          60                  0
''
''INTERCOMPUTER COMMUNICATIONS DATALINK - IC4
''          MODE   TRANSMISSION RATE     TIME LAG
10    4       0          60                  0
''
''INTERCOMPUTER COMMUNICATIONS DATALINK - IC5
''          MODE   TRANSMISSION RATE     TIME LAG
10    5       0          60                  0
''
''DISPLAY SYSTEM DATALINK - DK1
''          MODE   TRANSMISSION RATE     TIME LAG
10    6       0          60                  0
''
''DISPLAY SYSTEM DATALINK - DK2
''          MODE   TRANSMISSION RATE     TIME LAG
10    7       0          60                  0
''
''DISPLAY SYSTEM DATALINK - DK3
''          MODE   TRANSMISSION RATE     TIME LAG
10    8       0          60                  0
''
''FLIGHT CRITICAL BUS DATALINK - FC1
''          MODE   TRANSMISSION RATE     TIME LAG
10   10       0          60                  0
''
''FLIGHT CRITICAL BUS DATALINK - FC2
''          MODE   TRANSMISSION RATE     TIME LAG
10   11       0          60                  0
''
''FLIGHT CRITICAL BUS DATALINK - FC3
''          MODE   TRANSMISSION RATE     TIME LAG
10   12       0          60                  0
''
''FLIGHT CRITICAL BUS DATALINK - FC4
''          MODE   TRANSMISSION RATE     TIME LAG
10   13       0          60                  0
''
''FLIGHT CRITICAL BUS DATALINK - FC5
''          MODE   TRANSMISSION RATE     TIME LAG
10   14       0          60                  0
''
''FLIGHT CRITICAL BUS DATALINK - FC6
''          MODE   TRANSMISSION RATE     TIME LAG
10   15       0          60                  0
''
''FLIGHT CRITICAL BUS DATALINK - FC7
''          MODE   TRANSMISSION RATE     TIME LAG
```

```
10   16       0          60                    0
''
''FLIGHT CRITICAL BUS DATALINK - FC8
''           MODE    TRANSMISSION RATE      TIME LAG
10   17       0          60                    0
''
''MASS MEMORY DATALINK - MM1
''           MODE    TRANSMISSION RATE      TIME LAG
10   18       0          60                  500
''
''MASS MEMORY DATALINK - MM2
''           MODE    TRANSMISSION RATE      TIME LAG
10   19       0          60                  500
''
''MISSION CRITICAL DATALINK - PL1
''           MODE    TRANSMISSION RATE      TIME LAG
10   20       0          60                    0
''
''MISSION CRITICAL DATALINK - PL2
''           MODE    TRANSMISSION RATE      TIME LAG
10   21       0          60                    0
''
''GROUND INTERFACE DATALINK - LB1
''           MODE    TRANSMISSION RATE      TIME LAG
10   22       0          60                    0
''
''GROUND INTERFACE DATALINK - LB2
''           MODE    TRANSMISSION RATE      TIME LAG
10   23       0          60                    0
''
''PCMMU DATALINK - IP1
''           MODE    TRANSMISSION RATE      TIME LAG
10   24       0          60                    0
''
''PCMMU DATALINK - IP2
''           MODE    TRANSMISSION RATE      TIME LAG
10   25       0          60                    0
''
''PCMMU DATALINK - IP3
''           MODE    TRANSMISSION RATE      TIME LAG
10   26       0          60                    0
''
''PCMMU DATALINK - IP4
''           MODE    TRANSMISSION RATE      TIME LAG
10   27       0          60                    0
''
''DU1/DEU1 DATALINK
''           MODE    TRANSMISSION RATE      TIME LAG
10   29       0           1                    0
''
```

```
''DU2/DEU2 DATALINK
''          MODE   TRANSMISSION RATE     TIME LAG
10   30       0           1                 0
''
''DU3/DEU3 DATALINK
''          MODE   TRANSMISSION RATE     TIME LAG
10   31       0           1                 0
''
''KB1/DEU1 DATALINK
''          MODE   TRANSMISSION RATE     TIME LAG
10   33       0           1                 0
''
''KB1/DEU3 DATALINK
''          MODE   TRANSMISSION RATE     TIME LAG
10   34       0           1                 0
''
''KB2/DEU2 DATALINK
''          MODE   TRANSMISSION RATE     TIME LAG
10   35       0           1                 0
''
''KB2/DEU3 DATALINK
''          MODE   TRANSMISSION RATE     TIME LAG
10   36       0           1                 0
''
''
''**** DATA SETS ***************************************************
''
''     A DATA SET IS DEFINED TO REPRESENT THE DISPLAY IMAGES STORED IN
''     EACH OF THE TWO MASS MEMORIES.
''
''     STORAGE   ORG   INIT.SIZE   MAX.SIZE
''
11   1    1       0        10000      10000
11   2    1       0        10240      10240
''
''
''**** SYSTEM CONFIGURATION ****************************************
''
''     THE FOLLOWING FORMS DEFINE THE INTERCONNECTIONS OF DPS COMPONENTS
''     THROUGH DATA LINKS.
''
''      UNIT     DATALINK CONNECTIONS
12     60001      6  29  33
12     60002      7  30  35
12     60003      8  31  34  36
12     60005     29
12     60006     30
12     60007     31
12     60009     10  14
12     60010     11  15
```

```
12      60011      12  16
12      60012      13  17
12      60013      14  10
12      60014      15  11
12      60015      16  12
12      60016      17  13
12      60017      10  11  12  13
12      60018      10  11  12  13
12      60019      10  11  12  13
12      60027      33  34
12      60028      35  36
12      60030      22  23
12      60031      22  23
12      60032      22  23
12      60033      22  23
12      60034      22  23
12      60035      22  23
12      60036      20  21
12      60037      20  21
12      60095      24  25  26  27
12      60096      24  25  26  27
12      70001       1   2   3   4   5   6   7   8      10  11  12  13   *
                   14  15  16  17  18  19  20  21  22  23  24
12      70002       1   2  25
12      70003       1   3  26
12      70004       1   4  27
12      70011      14  15  16  17
12      70012      14  15  16  17
12      70013      14  15  16  17
12      70014      14  15  16  17
12      70015      14  15  16  17
12      80001      18
12      80002      19
''
''
''**** ALGORITHM SELECTION ********************************************
''
''     1A  1B  2A  2B  2C  2D  2E  3A  3B  3C  4A  4B  5A  5B  6A
13      1   0   1   1   0   0   0   1   1   1   1   1   0   0   0
''
''
''**** VIRTUAL MACHINES ***********************************************
''
''      ONLY ONE VIRTUAL MACHINE IS NEEDED TO REPRESENT THE DDPC FOR THE
''      PURPOSE OF THE CURRENT LOADING STUDY.  HOWEVER, THREE ADDITIONAL
''      VM'S ARE INCLUDED TO DEMONSTRATE A REDUNDANT SET OF FOUR GPC'S.
''
''           EXECUTIVE MEM     VM SIZE         VM PAGE SIZE
14      1          1          1744000             2048
''      2          2          1744000             2048
```

''	3	3	1744000	2048
''	4	4	1744000	2048

APPENDIX C

HISTORY PRINTOUT

This appendix provides the History Printout of a simulation run during part of Major Mode 101, transition to Major Mode 102, and part of Major Mode 102

The abbreviations used in this appendix, in order of appearance, are as follows·

TUS - Time Units
TS - Task Starts
TI - Task Index (internal IMSIM index)
TG - Go (Activation) for task
T X - Task in Execution
MS - Message Starts
M E - Message Ends
T W - Task in Wait State
T E - Task Ends
T I- Task Interrupt

This printout gives the full history of the run by providing pertinent information every time that an activity in the model takes place. This history specifies, at the time indicated, one or more of the following types of summaries

a The start and finish of jobs

b The start, cyclic go condition, execution, abort, interrupt, wait, and completion times of tasks, and the appropriate job number for which this task is called

c. For messages, the task and job number as well as the message length, transmission rate, transmission path consisting of the origin (source), bus, or datalink used for transmission, and the destination (sink)

d Events taking place at the stated times, such as Major Mode transition, regular event occurrence during a Major Mode, and special events, such as Vehicle Safing, OMS failure, Hold Count, etc.

At time 2, the Executive Functions are initialized, while at time 20 through 50 all Principal Functions (tasks) are initiated. The "Go" conditions for activation are started at time 1900 (Countdown T_0 - 1) and continue through countdown = 0 and liftoff to Event 2 in the First Stage Major Mode 102.

This printout is one of many history printouts that are available for inspection at SDC in Santa Monica, California.

```
     2 TUS          START  AT      0   SEC.  JOB      1
     2 TUS    TS    START      TASK       1  JOB      1 TI=701
     2 TUS    TS    START      TASK       2  JOB      1 TI=702
     2 TUS    TS    START      TASK       3  JOB      1 TI=703
     2 TUS    TS    START      TASK       4  JOB      1 TI=704
     2 TUS    TS    START      TASK       5  JOB      1 TI=705
** AT TIME      2 COUNTDOWN CLOCK IS AT -    1 SECONDS AND COUNTING.
    20 TUS          START  AT      0.02SEC.  JOB      2
    20 TUS    TS    START      TASK       6  JOB      2 TI=706
    20 TUS    TS    START      TASK       7  JOB      2 TI=707
    20 TUS    TS    START      TASK       8  JOB      2 TI=708
    20 TUS    TS    START      TASK      15  JOB      2 TI=709
    20 TUS    TS    START      TASK      19  JOB      2 TI=710
    20 TUS    TS    START      TASK      36  JOB      2 TI=711
    20 TUS    TS    START      TASK      52  JOB      2 TI=712
    20 TUS    TS    START      TASK      97  JOB      2 TI=713
    20 TUS    TS    START      TASK     165  JOB      2 TI=714
    20 TUS    TS    START      TASK     168  JOB      2 TI=715
    20 TUS    TS    START      TASK     176  JOB      2 TI=716
    20 TUS    TS    START      TASK     180  JOB      2 TI=717
    20 TUS    TS    START      TASK     197  JOB      2 TI=718
    20 TUS    TS    START      TASK     201  JOB      2 TI=719
    20 TUS    TS    START      TASK     203  JOB      2 TI=720
    20 TUS    TS    START      TASK     206  JOB      2 TI=721
    20 TUS    TS    START      TASK     210  JOB      2 TI=722
    20 TUS    TS    START      TASK     306  JOB      2 TI=723
    20 TUS    TS    START      TASK     309  JOB      2 TI=724
    20 TUS    TS    START      TASK     319  JOB      2 TI=725
    30 TUS          START  AT      0.03SEC.  JOB      3
    30 TUS    TS    START      TASK      40  JOB      3 TI=726
    30 TUS    TS    START      TASK      41  JOB      3 TI=727
    30 TUS    TS    START      TASK      42  JOB      3 TI=728
    30 TUS    TS    START      TASK      45  JOB      3 TI=729
    30 TUS    TS    START      TASK      49  JOB      3 TI=730
    30 TUS    TS    START      TASK      50  JOB      3 TI=731
    30 TUS    TS    START      TASK      54  JOB      3 TI=732
    30 TUS    TS    START      TASK      60  JOB      3 TI=733
    30 TUS    TS    START      TASK      62  JOB      3 TI=734
    30 TUS    TS    START      TASK      64  JOB      3 TI=735
    30 TUS    TS    START      TASK      65  JOB      3 TI=736
    30 TUS    TS    START      TASK     101  JOB      3 TI=737
    30 TUS    TS    START      TASK     102  JOB      3 TI=738
    30 TUS    TS    START      TASK     119  JOB      3 TI=739
    30 TUS    TS    START      TASK     120  JOB      3 TI=740
    30 TUS    TS    START      TASK     171  JOB      3 TI=741
    30 TUS    TS    START      TASK     181  JOB      3 TI=742
    30 TUS    TS    START      TASK     188  JOB      3 TI=743
    30 TUS    TS    START      TASK     190  JOB      3 TI=744
    30 TUS    TS    START      TASK     193  JOB      3 TI=745
    40 TUS          START  AT      0 04SEC.  JOB      4
```

```
  40 TUS     TS      START       TASK       70  JOB       4 TI=746
  40 TUS     TS      START       TASK       91  JOB       4 TI=747
  40 TUS     TS      START       TASK       92  JOB       4 TI=748
  40 TUS     TS      START       TASK       95  JOB       4 TI=749
  40 TUS     TS      START       TASK      110  JOB       4 TI=750
  40 TUS     TS      START       TASK      114  JOB       4 TI=751
  40 TUS     TS      START       TASK      115  JOB       4 TI=752
  40 TUS     TS      START       TASK      116  JOB       4 TI=753
  40 TUS     TS      START       TASK      161  JOB       4 TI=754
  40 TUS     TS      START       TASK      164  JOB       4 TI=755
  40 TUS     TS      START       TASK      175  JOB       4 TI=756
  40 TUS     TS      START       TASK      182  JOB       4 TI=757
  40 TUS     TS      START       TASK      183  JOB       4 TI=758
  50 TUS             START  AT       0.05SEC.  JOB       5
  50 TUS     TS      START       TASK      307  JOB       5 TI=759
  50 TUS     TS      START       TASK      332  JOB       5 TI=760
  50 TUS     TS      START       TASK      333  JOB       5 TI=761
  50 TUS     TS      START       TASK      334  JOB       5 TI=762
  50 TUS     TS      START       TASK      335  JOB       5 TI=763
  50 TUS     TS      START       TASK      337  JOB       5 TI=764
1900 TUS MS          START  28   TASK      307  JOB       5 TI=759 LENGTH  RATE
                     PATH  70004          1        70001              256    60
1900 TUS MS          START  29   TASK      307  JOB       5 TI=759 LENGTH  RATE
                     PATH  70001          4        70004              256    60
1900 TUS MS          START  29   TASK      307  JOB       5 TI=759 LENGTH  RATE
                     PATH  70001          3        70003              256    60
1900 TUS MS          START  29   TASK      307  JOB       5 TI=759 LENGTH  RATE
                     PATH  70001          2        70002              256    60
1900 TUS     TG      GO FOR      TASK      307
1900 TUS     T X     EXECUTING   TASK      307  JOB       5 TI=759
1900 TUS MS          START  58   TASK      307  JOB       5 TI=759 LENGTH  RATE
                     PATH  70001         24        60095              512    60
1900 TUS     TG      GO FOR      TASK      181
1900 TUS     TG      GO FOR      TASK      306
1900 TUS     TG      GO FOR      TASK      176
1900 TUS     TG      GO FOR      TASK      309
1900 TUS     TG      GO FOR      TASK       62
1900 TUS     TG      GO FOR      TASK       40
1900 TUS     TG      GO FOR      TASK       60
1900 TUS     TG      GO FOR      TASK       91
1900 TUS     TG      GO FOR      TASK       41
1900 TUS     TG      GO FOR      TASK      180
1900 TUS     TG      GO FOR      TASK       50
1900 TUS     TG      GO FOR      TASK      332
1900 TUS     TG      GO FOR      TASK      203
1900 TUS     TG      GO FOR      TASK      319
1900 TUS     TG      GO FOR      TASK       52
1900 TUS     TG      GO FOR      TASK      110
1900 TUS     TG      GO FOR      TASK      120
1900 TUS     TG      GO FOR      TASK       97
```

```
1900 TUS    TG     GO FOR     TASK     102
1900 TUS    TG     GO FOR     TASK     119
1900 TUS    TG     GO FOR     TASK     101
1900 TUS    TG     GO FOR     TASK      42
1900 TUS    TG     GO FOR     TASK     337
1900 TUS    TG     GO FOR     TASK     114
1900 TUS    TG     GO FOR     TASK     335
1900 TUS    TG     GO FOR     TASK      49
1900 TUS    TG     GO FOR     TASK      95
1900 TUS    TG     GO FOR     TASK     206
1900 TUS    TG     GO FOR     TASK     333
1900 TUS    TG     GO FOR     TASK      19
1900 TUS    TG     GO FOR     TASK      15
1900 TUS    TG     GO FOR     TASK     168
1900 TUS    TG     GO FOR     TASK     197
1903 TUS    T   W  MSG WAIT   TASK     307  JOB      5 TI=759
1903 TUS    T X    EXECUTING  TASK     306  JOB      2 TI=723
1903 TUS MS        START  10  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  70001        12       60011              2    60
1903 TUS M E       END    10  TASK     306  JOB      2 TI=723
1903 TUS MS        START  10  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  70001        11       60010              2    60
1903 TUS M E       END    10  TASK     306  JOB      2 TI=723
1903 TUS MS        START  11  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  60011        12       70001             32    60
1903 TUS M E       END    11  TASK     306  JOB      2 TI=723
1903 TUS MS        START  10  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  70001        10       60009              2    60
1903 TUS M E       END    10  TASK     306  JOB      2 TI=723
1903 TUS MS        START  11  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  60010        11       70001             32    60
1903 TUS M E       END    11  TASK     306  JOB      2 TI=723
1903 TUS MS        START  11  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  60009        10       70001             32    60
1903 TUS M E       END    11  TASK     306  JOB      2 TI=723
1903 TUS MS        START  20  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  70001        12       60011              2    60
1903 TUS M E       END    20  TASK     306  JOB      2 TI=723
1903 TUS MS        START  20  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  70001        11       60010              2    60
1903 TUS M E       END    20  TASK     306  JOB      2 TI=723
1903 TUS MS        START  21  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  60011        12       70001             18    60
1903 TUS M E       END    21  TASK     306  JOB      2 TI=723
1903 TUS MS        START  20  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  70001        10       60009              2    60
1903 TUS M E       END    20  TASK     306  JOB      2 TI=723
1903 TUS MS        START  21  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  60010        11       70001             18    60
1903 TUS M E       END    21  TASK     306  JOB      2 TI=723
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1903 TUS MS       START  21  TASK    306  JOB      2 TI=723 LENGTH  RATE
                  PATH  60009       10       70001              18    60
1903 TUS M E      END    21  TASK    306  JOB      2 TI=723
1903 TUS MS       START  52  TASK    306  JOB      2 TI=723 LENGTH  RATE
                  PATH  70001       12       60011               4    60
1903 TUS M E      END    52  TASK    306  JOB      2 TI=723
1903 TUS MS       START  52  TASK    306  JOB      2 TI=723 LENGTH  RATE
                  PATH  70001       11       60010               4    60
1903 TUS M E      END    52  TASK    306  JOB      2 TI=723
1903 TUS MS       START  52  TASK    306  JOB      2 TI=723 LENGTH  RATE
                  PATH  70001       10       60009               4    60
1903 TUS M E      END    52  TASK    306  JOB      2 TI=723
1903 TUS    T  E  END        TASK    306  JOB      2 TI=723
1903 TUS    T X   EXECUTING  TASK    309  JOB      2 TI=724
1904 TUS M E      END    28  TASK    307  JOB      5 TI=759
1904 TUS M E      END    29  TASK    307  JOB      5 TI=759
1904 TUS M E      END    29  TASK    307  JOB      5 TI=759
1904 TUS M E      END    29  TASK    307  JOB      5 TI=759
1904 TUS MS       START  28  TASK    307  JOB      5 TI=759 LENGTH  RATE
                  PATH  70003        1       70001             256    60
1906 TUS    T  E  END        TASK    309  JOB      2 TI=724
1906 TUS    T X   EXECUTING  TASK    181  JOB      3 TI=742
1906 TUS MS       START  34  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       14       70013               2    60
1906 TUS M E      END    34  TASK    181  JOB      3 TI=742
1906 TUS MS       START  34  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       14       70012                    2    60
1906 TUS M E      END    34  TASK    181  JOB      3 TI=742
1906 TUS MS       START  35  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70013       14       70001              64    60
1906 TUS MS       START  34  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       15       70011               2    60
1906 TUS M E      END    34  TASK    181  JOB      3 TI=742
1906 TUS MS       START  35  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70012       15       70001              64    60
1906 TUS MS       START  35  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70011       16       70001              64    60
1906 TUS MS       START  50  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       12       60011               8    60
1906 TUS M E      END    50  TASK    181  JOB      3 TI=742
1906 TUS MS       START  50  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       10       60009               8    60
1906 TUS M E      END    50  TASK    181  JOB      3 TI=742
1907 TUS M E      END    35  TASK    181  JOB      3 TI=742
1907 TUS M E      END    35  TASK    181  JOB      3 TI=742
1907 TUS M E      END    35  TASK    181  JOB      3 TI=742
1907 TUS MS       START  61  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       17       70011               4    60
1907 TUS M E      END    61  TASK    181  JOB      3 TI=742
1907 TUS MS       START  62  TASK    181  JOB      3 TI=742 LENGTH  RATE
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                    PATH  70001        14        70012                  4    60
1907 TUS M E        END    62  TASK     181  JOB       3 TI=742
1907 TUS MS         START  63  TASK     181  JOB       3 TI=742 LENGTH  RATE
                    PATH  70001        14        70013                  4    60
1907 TUS M E        END    63  TASK     181  JOB       3 TI=742
1907 TUS    T  E    END        TASK     181  JOB       3 TI=742
1907 TUS    T X     EXECUTING  TASK     176  JOB       2 TI=716
1908 TUS M E        END    58  TASK     307  JOB       5 TI=759
1908 TUS M E        END    28  TASK     307  JOB       5 TI=759
1908 TUS MS         START  28  TASK     307  JOB       5 TI=759 LENGTH  RATE
                    PATH  70002         1        70001                256    60
1912 TUS M E        END    28  TASK     307  JOB       5 TI=759
1912 TUS    T  E    END        TASK     307  JOB       5 TI=759
1916 TUS    T  E    END        TASK     176  JOB       2 TI=716
1916 TUS    T X     EXECUTING  TASK      62  JOB       3 TI=734
1916 TUS MS         START  64  TASK      62  JOB       3 TI=734 LENGTH  RATE
                    PATH  70001        10        60013                 10    60
1916 TUS M E        END    64  TASK      62  JOB       3 TI=734
1916 TUS MS         START  65  TASK      62  JOB       3 TI=734 LENGTH  RATE
                    PATH  70001        11        60014                 10    60
1916 TUS M E        END    65  TASK      62  JOB       3 TI=734
1916 TUS MS         START  66  TASK      62  JOB       3 TI=734 LENGTH  RATE
                    PATH  70001        12        60015                 10    60
1916 TUS M E        END    66  TASK      62  JOB       3 TI=734
1916 TUS MS         START  67  TASK      62  JOB       3 TI=734 LENGTH  RATE
                    PATH  70001        13        60016                 10    60
1916 TUS M E        END    67  TASK      62  JOB       3 TI=734
1917 TUS    T  E    END        TASK      62  JOB       3 TI=734
1917 TUS    T X     EXECUTING  TASK      60  JOB       3 TI=733
1917 TUS MS         START  64  TASK      60  JOB       3 TI=733 LENGTH  RATE
                    PATH  70001        10        60013                 14    60
1917 TUS M E        END    64  TASK      60  JOB       3 TI=733
1917 TUS MS         START  65  TASK      60  JOB       3 TI=733 LENGTH  RATE
                    PATH  70001        11        60014                 14    60
1917 TUS M E        END    65  TASK      60  JOB       3 TI=733
1917 TUS MS         START  66  TASK      60  JOB       3 TI=733 LENGTH  RATE
                    PATH  70001        12        60015                 14    60
1917 TUS M E        END    66  TASK      60  JOB       3 TI=733
1917 TUS MS         START  67  TASK      60  JOB       3 TI=733 LENGTH  RATE
                    PATH  70001        13        60016                 14    60
1917 TUS M E        END    67  TASK      60  JOB       3 TI=733
1918 TUS    T  E    END        TASK      60  JOB       3 TI=733
1918 TUS    T X     EXECUTING  TASK      41  JOB       3 TI=727
1918 TUS MS         START  22  TASK      41  JOB       3 TI=727 LENGTH  RATE
                    PATH  70001        12        60015                  2    60
1918 TUS M E        END    22  TASK      41  JOB       3 TI=727
1918 TUS MS         START  22  TASK      41  JOB       3 TI=727 LENGTH  RATE
                    PATH  70001        11        60014                  2    60
1918 TUS M E        END    22  TASK      41  JOB       3 TI=727
1918 TUS MS         START  23  TASK      41  JOB       3 TI=727 LENGTH  RATE
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                    PATH  60015        12        70001                  8    60
1918 TUS M E        END    23  TASK      41  JOB       3 TI=727
1918 TUS MS         START  22  TASK      41  JOB       3 TI=727 LENGTH  RATE
                    PATH  70001        10        60013                  2    60
1918 TUS M E        END    22  TASK      41  JOB       3 TI=727
1918 TUS MS         START  23  TASK      41  JOB       3 TI=727 LENGTH  RATE
                    PATH  60014        11        70001                  8    60
1918 TUS M E        END    23  TASK      41  JOB       3 TI=727
1918 TUS MS         START  23  TASK      41  JOB       3 TI=727 LENGTH  RATE
                    PATH  60013        10        70001                  8    60
1918 TUS M E        END    23  TASK      41  JOB       3 TI=727
1918 TUS    T  E    END        TASK      41  JOB       3 TI=727
1918 TUS    T X     EXECUTING  TASK      40  JOB       3 TI=726
1918 TUS MS         START  22  TASK      40  JOB       3 TI=726 LENGTH  RATE
                    PATH  70001        12        60015                  2    60
1918 TUS M E        END    22  TASK      40  JOB       3 TI=726
1918 TUS MS         START  22  TASK      40  JOB       3 TI=726 LENGTH  RATE
                    PATH  70001        11        60014                  2    60
1918 TUS M E        END    22  TASK      40  JOB       3 TI=726
1918 TUS MS         START  23  TASK      40  JOB       3 TI=726 LENGTH  RATE
                    PATH  60015        12        70001                  8    60
1918 TUS M E        END    23  TASK      40  JOB       3 TI=726
1918 TUS MS         START  22  TASK      40  JOB       3 TI=726 LENGTH  RATE
                    PATH  70001        10        60013                  2    60
1918 TUS M E        END    22  TASK      40  JOB       3 TI=726
1918 TUS MS         START  23  TASK      40  JOB       3 TI=726 LENGTH  RATE
                    PATH  60014        11        70001                  8    60
1918 TUS M E        END    23  TASK      40  JOB       3 TI=726
1918 TUS MS         START  23  TASK      40  JOB       3 TI=726 LENGTH  RATE
                    PATH  60013        10        70001                  8    60
1918 TUS M E        END    23  TASK      40  JOB       3 TI=726
1919 TUS    T  E    END        TASK      40  JOB       3 TI=726
1919 TUS    T X     EXECUTING  TASK      50  JOB       3 TI=731
1919 TUS MS         START  53  TASK      50  JOB       3 TI=731 LENGTH  RATE
                    PATH  70001        13        60016                 14    60
1919 TUS M E        END    53  TASK      50  JOB       3 TI=731
1919 TUS MS         START  53  TASK      50  JOB       3 TI=731 LENGTH  RATE
                    PATH  70001        12        60015                 14    60
1919 TUS M E        END    53  TASK      50  JOB       3 TI=731
1919 TUS MS         START  53  TASK      50  JOB       3 TI=731 LENGTH  RATE
                    PATH  70001        11        60014                 14    60
1919 TUS M E        END    53  TASK      50  JOB       3 TI=731
1919 TUS MS         START  53  TASK      50  JOB       3 TI=731 LENGTH  RATE
                    PATH  70001        10        60013                 14    60
1919 TUS M E        END    53  TASK      50  JOB       3 TI=731
1920 TUS    T  E    END        TASK      50  JOB       3 TI=731
1920 TUS    T X     EXECUTING  TASK      97  JOB       2 TI=713
1930 TUS    T  E    END        TASK      97  JOB       2 TI=713
1930 TUS    T X     EXECUTING  TASK     203  JOB       2 TI=720
1930 TUS MS         START  44  TASK     203  JOB       2 TI=720 LENGTH  RATE
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                PATH  70001        22        60033                2    60
1930 TUS M E    END    44  TASK     203  JOB       2 TI=720
1930 TUS MS     START  44  TASK     203  JOB       2 TI=720 LENGTH  RATE
                PATH  70001        22        60032                2    60
1930 TUS M E    END    44  TASK     203  JOB       2 TI=720
1930 TUS MS     START  45  TASK     203  JOB       2 TI=720 LENGTH  RATE
                PATH  60033        22        70001               48    60
1930 TUS M E    END    45  TASK     203  JOB       2 TI=720
1930 TUS MS     START  44  TASK     203  JOB       2 TI=720 LENGTH  RATE
                PATH  70001        23        60031                2    60
1930 TUS M E    END    44  TASK     203  JOB       2 TI=720
1930 TUS MS     START  45  TASK     203  JOB       2 TI=720 LENGTH  RATE
                PATH  60032        23        70001               38    60
1930 TUS M E    END    45  TASK     203  JOB       2 TI=720
1930 TUS MS     START  44  TASK     203  JOB       2 TI=720 LENGTH  RATE
                PATH  70001        22        60030                2    60
1930 TUS M E    END    44  TASK     203  JOB       2 TI=720
1930 TUS MS     START  45  TASK     203  JOB       2 TI=720 LENGTH  RATE
                PATH  60031        22        70001               42    60
1930 TUS M E    END    45  TASK     203  JOB       2 TI=720
1930 TUS MS     START  45  TASK     203  JOB       2 TI=720 LENGTH  RATE
                PATH  60030        23        70001               32    60
1930 TUS M E    END    45  TASK     203  JOB       2 TI=720
1931 TUS    T  E END       TASK     203  JOB       2 TI=720
1931 TUS    T X EXECUTING  TASK      91  JOB       4 TI=747
1931 TUS MS     START   6  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  70001        12        60011                2    60
1931 TUS M E    END     6  TASK      91  JOB       4 TI=747
1931 TUS MS     START   6  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  70001        11        60010                2    60
1931 TUS M E    END     6  TASK      91  JOB       4 TI=747
1931 TUS MS     START   7  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  60011        12        70001                2    60
1931 TUS M E    END     7  TASK      91  JOB       4 TI=747
1931 TUS MS     START   6  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  70001        10        60009                2    60
1931 TUS M E    END     6  TASK      91  JOB       4 TI=747
1931 TUS MS     START   7  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  60010        11        70001                2    60
1931 TUS M E    END     7  TASK      91  JOB       4 TI=747
1931 TUS MS     START   7  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  60009        10        70001                2    60
1931 TUS M E    END     7  TASK      91  JOB       4 TI=747
1931 TUS MS     START  22  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  70001        12        60015                2    60
1931 TUS M E    END    22  TASK      91  JOB       4 TI=747
1931 TUS MS     START  22  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  70001        11        60014                2    60
1931 TUS M E    END    22  TASK      91  JOB       4 TI=747
1931 TUS MS     START  23  TASK      91  JOB       4 TI=747 LENGTH  RATE
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                PATH  60015        12        70001                    2    60
1931 TUS M E    END    23  TASK      91  JOB       4 TI=747
1931 TUS MS     START  22  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  70001        10        60013                    2    60
1931 TUS M E    END    22  TASK      91  JOB       4 TI=747
1931 TUS MS     START  23  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  60014        11        70001                    2    60
1931 TUS M E    END    23  TASK      91  JOB       4 TI=747
1931 TUS MS     START  23  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  60013        10        70001                    2    60
1931 TUS M E    END    23  TASK      91  JOB       4 TI=747
1931 TUS MS     START  38  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  70001        13        60012                    2    60
1931 TUS M E    END    38  TASK      91  JOB       4 TI=747
1931 TUS MS     START  38  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  70001        12        60011                    2    60
1931 TUS M E    END    38  TASK      91  JOB       4 TI=747
1931 TUS MS     START  39  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  60012        13        70001                   20    60
1931 TUS M E    END    39  TASK      91  JOB       4 TI=747
1931 TUS MS     START  38  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  70001        11        60010                    2    60
1931 TUS M E    END    38  TASK      91  JOB       4 TI=747
1931 TUS MS     START  39  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  60011        12        70001                   32    60
1931 TUS M E    END    39  TASK      91  JOB       4 TI=747
1931 TUS MS     START  38  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  70001        10        60009                    2    60
1931 TUS M E    END    38  TASK      91  JOB       4 TI=747
1931 TUS MS     START  39  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  60010        11        70001                   20    60
1931 TUS M E    END    39  TASK      91  JOB       4 TI=747
1931 TUS MS     START  39  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  60009        10        70001                   32    60
1931 TUS M E    END    39  TASK      91  JOB       4 TI=747
1931 TUS MS     START  46  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  70001        13        60016                    2    60
1931 TUS M E    END    46  TASK      91  JOB       4 TI=747
1931 TUS MS     START  46  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  70001        12        60015                    2    60
1931 TUS M E    END    46  TASK      91  JOB       4 TI=747
1931 TUS MS     START  47  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  60016        13        70001                    4    60
1931 TUS M E    END    47  TASK      91  JOB       4 TI=747
1931 TUS MS     START  46  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  70001        11        60014                    2    60
1931 TUS M E    END    46  TASK      91  JOB       4 TI=747
1931 TUS MS     START  47  TASK      91  JOB       4 TI=747 LENGTH  RATE
                PATH  60015        12        70001                    4    60
1931 TUS M E    END    47  TASK      91  JOB       4 TI=747
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1931 TUS MS       START  46  TASK     91  JOB      4 TI=747 LENGTH  RATE
                  PATH  70001      10       60013                2    60
1931 TUS M E      END    46  TASK     91  JOB      4 TI=747
1931 TUS MS       START  47  TASK     91  JOB      4 TI=747 LENGTH  RATE
                  PATH  60014      11       70001                4    60
1931 TUS M E      END    47  TASK     91  JOB      4 TI=747
1931 TUS MS       START  47  TASK     91  JOB      4 TI=747 LENGTH  RATE
                  PATH  60013      10       70001                4    60
1931 TUS M E      END    47  TASK     91  JOB      4 TI=747
1933 TUS    T  E  END        TASK     91  JOB      4 TI=747
1933 TUS    T X   EXECUTING  TASK     52  JOB      2 TI=712
1933 TUS MS       START  22  TASK     52  JOB      2 TI=712 LENGTH  RATE
                  PATH  70001      12       60015                2    60
1933 TUS M E      END    22  TASK     52  JOB      2 TI=712
1933 TUS MS       START  22  TASK     52  JOB      2 TI=712 LENGTH  RATE
                  PATH  70001      11       60014                2    60
1933 TUS M E      END    22  TASK     52  JOB      2 TI=712
1933 TUS MS       START  23  TASK     52  JOB      2 TI=712 LENGTH  RATE
                  PATH  60015      12       70001                4    60
1933 TUS M E      END    23  TASK     52  JOB      2 TI=712
1933 TUS MS       START  22  TASK     52  JOB      2 TI=712 LENGTH  RATE
                  PATH  70001      10       60013                2    60
1933 TUS M E      END    22  TASK     52  JOB      2 TI=712
1933 TUS MS       START  23  TASK     52  JOB      2 TI=712 LENGTH  RATE
                  PATH  60014      11       70001                4    60
1933 TUS M E      END    23  TASK     52  JOB      2 TI=712
1933 TUS MS       START  23  TASK     52  JOB      2 TI=712 LENGTH  RATE
                  PATH  60013      10       70001                4    60
1933 TUS M E      END    23  TASK     52  JOB      2 TI=712
1934 TUS    T  E  END        TASK     52  JOB      2 TI=712
1934 TUS    T X   EXECUTING  TASK    120  JOB      3 TI=740
1934 TUS MS       START  22  TASK    120  JOB      3 TI=740 LENGTH  RATE
                  PATH  70001      12       60015                2    60
1934 TUS M E      END    22  TASK    120  JOB      3 TI=740
1934 TUS MS       START  22  TASK    120  JOB      3 TI=740 LENGTH  RATE
                  PATH  70001      11       60014                2    60
1934 TUS M E      END    22  TASK    120  JOB      3 TI=740
1934 TUS MS       START  23  TASK    120  JOB      3 TI=740 LENGTH  RATE
                  PATH  60015      12       70001                8    60
1934 TUS M E      END    23  TASK    120  JOB      3 TI=740
1934 TUS MS       START  22  TASK    120  JOB      3 TI=740 LENGTH  RATE
                  PATH  70001      10       60013                2    60
1934 TUS M E      END    22  TASK    120  JOB      3 TI=740
1934 TUS MS       START  23  TASK    120  JOB      3 TI=740 LENGTH  RATE
                  PATH  60014      11       70001                8    60
1934 TUS M E      END    23  TASK    120  JOB      3 TI=740
1934 TUS MS       START  23  TASK    120  JOB      3 TI=740 LENGTH  RATE
                  PATH  60013      10       70001                8    60
1934 TUS M E      END    23  TASK    120  JOB      3 TI=740
1934 TUS MS       START  46  TASK    120  JOB      3 TI=740 LENGTH  RATE
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                    PATH  70001      13       60016                2    60
1934 TUS M E        END    46  TASK    120  JOB      3 TI=740
1934 TUS MS         START  46  TASK    120  JOB      3 TI=740 LENGTH  RATE
                    PATH  70001      12       60015                2    60
1934 TUS M E        END    46  TASK    120  JOB      3 TI=740
1934 TUS MS         START  47  TASK    120  JOB      3 TI=740 LENGTH  RATE
                    PATH  60016      13       70001                2    60
1934 TUS M E        END    47  TASK    120  JOB      3 TI=740
1934 TUS MS         START  46  TASK    120  JOB      3 TI=740 LENGTH  RATE
                    PATH  70001      11       60014                2    60
1934 TUS M E        END    46  TASK    120  JOB      3 TI=740
1934 TUS MS         START  47  TASK    120  JOB      3 TI=740 LENGTH  RATE
                    PATH  60015      12       70001                2    60
1934 TUS M E        END    47  TASK    120  JOB      3 TI=740
1934 TUS MS         START  46  TASK    120  JOB      3 TI=740 LENGTH  RATE
                    PATH  70001      10       60013                2    60
1934 TUS M E        END    46  TASK    120  JOB      3 TI=740
1934 TUS MS         START  47  TASK    120  JOB      3 TI=740 LENGTH  RATE
                    PATH  60014      11       70001                2    60
1934 TUS M E        END    47  TASK    120  JOB      3 TI=740
1934 TUS MS         START  47  TASK    120  JOB      3 TI=740 LENGTH  RATE
                    PATH  60013      10       70001                2    60
1934 TUS M E        END    47  TASK    120  JOB      3 TI=740
1935 TUS    T  E    END        TASK    120  JOB      3 TI=740
1935 TUS    T X     EXECUTING  TASK    119  JOB      3 TI=739
1935 TUS MS         START  46  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  70001      13       60016                2    60
1935 TUS M E        END    46  TASK    119  JOB      3 TI=739
1935 TUS MS         START  46  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  70001      12       60015                2    60
1935 TUS M E        END    46  TASK    119  JOB      3 TI=739
1935 TUS MS         START  47  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  60016      13       70001                2    60
1935 TUS M E        END    47  TASK    119  JOB      3 TI=739
1935 TUS MS         START  46  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  70001      11       60014                2    60
1935 TUS M E        END    46  TASK    119  JOB      3 TI=739
1935 TUS MS         START  47  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  60015      12       70001                2    60
1935 TUS M E        END    47  TASK    119  JOB      3 TI=739
1935 TUS MS         START  46  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  70001      10       60013                2    60
1935 TUS M E        END    46  TASK    119  JOB      3 TI=739
1935 TUS MS         START  47  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  60014      11       70001                2    60
1935 TUS M E        END    47  TASK    119  JOB      3 TI=739
1935 TUS MS         START  47  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  60013      10       70001                2    60
1935 TUS M E        END    47  TASK    119  JOB      3 TI=739
1936 TUS    T  E    END        TASK    119  JOB      3 TI=739
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1936 TUS    T X   EXECUTING  TASK     42  JOB      3 TI=728
1936 TUS MS       START   6  TASK     42  JOB      3 TI=728 LENGTH  RATE
                  PATH  70001       12       60011              2    60
1936 TUS M E      END     6  TASK     42  JOB      3 TI=728
1936 TUS MS       START   6  TASK     42  JOB      3 TI=728 LENGTH  RATE
                  PATH  70001       11       60010              2    60
1936 TUS M E      END     6  TASK     42  JOB      3 TI=728
1936 TUS MS       START   7  TASK     42  JOB      3 TI=728 LENGTH  RATE
                  PATH  60011       12       70001              4    60
1936 TUS M E      END     7  TASK     42  JOB      3 TI=728
1936 TUS MS       START   6  TASK     42  JOB      3 TI=728 LENGTH  RATE
                  PATH  70001       10       60009              2    60
1936 TUS M E      END     6  TASK     42  JOB      3 TI=728
1936 TUS MS       START   7  TASK     42  JOB      3 TI=728 LENGTH  RATE
                  PATH  60010       11       70001              4    60
1936 TUS M E      END     7  TASK     42  JOB      3 TI=728
1936 TUS MS       START   7  TASK     42  JOB      3 TI=728 LENGTH  RATE
                  PATH  60009       10       70001              4    60
1936 TUS M E      END     7  TASK     42  JOB      3 TI=728
1937 TUS    T  E  END        TASK     42  JOB      3 TI=728
1937 TUS    T X   EXECUTING  TASK    114  JOB      4 TI=751
1937 TUS MS       START  24  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       13       60016              6    60
1937 TUS M E      END    24  TASK    114  JOB      4 TI=751
1937 TUS MS       START  24  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       12       60015              6    60
1937 TUS M E      END    24  TASK    114  JOB      4 TI=751
1937 TUS MS       START  25  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  60016       13       70001              2    60
1937 TUS M E      END    25  TASK    114  JOB      4 TI=751
1937 TUS MS       START  25  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  60015       12       70001              2    60
1937 TUS M E      END    25  TASK    114  JOB      4 TI=751
1937 TUS MS       START  26  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       11       60014              2    60
1937 TUS M E      END    26  TASK    114  JOB      4 TI=751
1937 TUS MS       START  26  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       10       60013              2    60
1937 TUS M E      END    26  TASK    114  JOB      4 TI=751
1937 TUS MS       START  27  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  60014       11       70001              2    60
1937 TUS M E      END    27  TASK    114  JOB      4 TI=751
1937 TUS MS       START  27  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  60013       10       70001              2    60
1937 TUS M E      END    27  TASK    114  JOB      4 TI=751
1937 TUS MS       START  64  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       10       60013              6    60
1937 TUS M E      END    64  TASK    114  JOB      4 TI=751
1937 TUS MS       START  65  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       11       60014              6    60
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1937 TUS M E      END    65  TASK    114  JOB      4 TI=751
1937 TUS MS       START  66  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       12       60015              6    60
1937 TUS M E      END    66  TASK    114  JOB      4 TI=751
1937 TUS MS       START  67  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       13       60016              6    60
1937 TUS M E      END    67  TASK    114  JOB      4 TI=751
1937 TUS MS       START  69  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       14       70015             24    60
1937 TUS M E      END    69  TASK    114  JOB      4 TI=751
1937 TUS MS       START  69  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       14       70014             24    60
1937 TUS M E      END    69  TASK    114  JOB      4 TI=751
1937 TUS MS       START  70  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       14       70015             24    60
1937 TUS M E      END    70  TASK    114  JOB      4 TI=751
1937 TUS MS       START  70  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       14       70014             24    60
1937 TUS M E      END    70  TASK    114  JOB      4 TI=751
1937 TUS MS       START  71  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       14       70015             24    60
1937 TUS M E      END    71  TASK    114  JOB      4 TI=751
1937 TUS MS       START  71  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       14       70014             24    60
1937 TUS M E      END    71  TASK    114  JOB      4 TI=751
1937 TUS MS       START  72  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       14       70015             24    60
1937 TUS M E      END    72  TASK    114  JOB      4 TI=751
1937 TUS MS       START  72  TASK    114  JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       14       70014             24    60
1937 TUS M E      END    72  TASK    114  JOB      4 TI=751
1938 TUS    T  E  END       TASK    114  JOB      4 TI=751
1938 TUS    T X   EXECUTING TASK    333  JOB      5 TI=761
1939 TUS    T  E  END       TASK    333  JOB      5 TI=761
1939 TUS    T X   EXECUTING TASK    180  JOB      2 TI=717
1939 TUS MS       START   6  TASK    180  JOB      2 TI=717 LENGTH  RATE
                  PATH  70001       12       60011              2    60
1939 TUS M E      END     6  TASK    180  JOB      2 TI=717
1939 TUS MS       START   6  TASK    180  JOB      2 TI=717 LENGTH  RATE
                  PATH  70001       11       60010              2    60
1939 TUS M E      END     6  TASK    180  JOB      2 TI=717
1939 TUS MS       START   7  TASK    180  JOB      2 TI=717 LENGTH  RATE
                  PATH  60011       12       70001              2    60
1939 TUS M E      END     7  TASK    180  JOB      2 TI=717
1939 TUS MS       START   6  TASK    180  JOB      2 TI=717 LENGTH  RATE
                  PATH  70001       10       60009              2    60
1939 TUS M E      END     6  TASK    180  JOB      2 TI=717
1939 TUS MS       START   7  TASK    180  JOB      2 TI=717 LENGTH  RATE
                  PATH  60010       11       70001              2    60
1939 TUS M E      END     7  TASK    180  JOB      2 TI=717
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REPRODUCIBILITY OF THE
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1939 TUS MS        START   7  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  60009       10       70001              2    60
1939 TUS M E       END     7  TASK    180  JOB      2 TI=717
1939 TUS MS        START  38  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  70001       13       60012              2    60
1939 TUS M E       END    38  TASK    180  JOB      2 TI=717
1939 TUS MS        START  38  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  70001       12       60011              2    60
1939 TUS M E       END    38  TASK    180  JOB      2 TI=717
1939 TUS MS        START  39  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  60012       13       70001              8    60
1939 TUS M E       END    39  TASK    180  JOB      2 TI=717
1939 TUS MS        START  38  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  70001       11       60010              2    60
1939 TUS M E       END    38  TASK    180  JOB      2 TI=717
1939 TUS MS        START  39  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  60011       12       70001             14    60
1939 TUS M E       END    39  TASK    180  JOB      2 TI=717
1939 TUS MS        START  38  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  70001       10       60009              2    60
1939 TUS M E       END    38  TASK    180  JOB      2 TI=717
1939 TUS MS        START  39  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  60010       11       70001             14    60
1939 TUS M E       END    39  TASK    180  JOB      2 TI=717
1939 TUS MS        START  39  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  60009       10       70001             14    60
1939 TUS M E       END    39  TASK    180  JOB      2 TI=717
1940 TUS    TG     GO FOR     TASK    307
1940 TUS    T    I INTERRUPT  TASK    180  JOB      2 TI=717
1940 TUS    TG     GO FOR     TASK    181
1940 TUS    T X    EXECUTING  TASK    307  JOB      5 TI=759
1940 TUS    TG     GO FOR     TASK    306
1940 TUS    T  E   END        TASK    180  JOB      2 TI=717
1940 TUS    TG     GO FOR     TASK    176
1940 TUS MS        START  29  TASK    307  JOB      5 TI=759 LENGTH  RATE
                   PATH  70001        1       70004            256    60
1940 TUS    TG     GO FOR     TASK    309
1940 TUS MS        START  29  TASK    307  JOB      5 TI=759 LENGTH  RATE
                   PATH  70001        3       70003            256    60
1940 TUS    TG     GO FOR     TASK     62
1940 TUS MS        START  29  TASK    307  JOB      5 TI=759 LENGTH  RATE
                   PATH  70001        2       70002            256    60
1940 TUS    TG     GO FOR     TASK     40
1940 TUS MS        START  28  TASK    307  JOB      5 TI=759 LENGTH  RATE
                   PATH  70004        4       70001            256    60
1940 TUS    TG     GO FOR     TASK     60
1940 TUS MS        START  58  TASK    307  JOB      5 TI=759 LENGTH  RATE
                   PATH  70001       24       60095            512    60
1940 TUS    TG     GO FOR     TASK     91
1940 TUS    TG     GO FOR     TASK     41
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1940 TUS     TG      GO FOR      TASK      50
1940 TUS     TG      GO FOR      TASK     203
1940 TUS     TG      GO FOR      TASK      52
1940 TUS     TG      GO FOR      TASK     120
1940 TUS     TG      GO FOR      TASK     119
1940 TUS     TG      GO FOR      TASK      42
1940 TUS     TG      GO FOR      TASK     333
1943 TUS     T   W   MSG WAIT    TASK     307  JOB      5 TI=759
1943 TUS     T X     EXECUTING   TASK     306  JOB      2 TI=723
1943 TUS     T   W   MSG WAIT    TASK     306  JOB      2 TI=723
1943 TUS     T X     EXECUTING   TASK     309  JOB      2 TI=724
1943 TUS MS          START  10   TASK     306  JOB      2 TI=723 LENGTH  RATE
                     PATH  70001        12       60011                2    60
1943 TUS M E         END    10   TASK     306  JOB      2 TI=723
1943 TUS     T    I  INTERRUPT   TASK     309  JOB      2 TI=724
1943 TUS     T X     EXECUTING   TASK     306  JOB      2 TI=723
1943 TUS     T   W   MSG WAIT    TASK     306  JOB      2 TI=723
1943 TUS     T X     EXECUTING   TASK     309  JOB      2 TI=724
1943 TUS MS          START  20   TASK     306  JOB      2 TI=723 LENGTH  RATE
                     PATH  70001        12       60011                2    60
1943 TUS M E         END    20   TASK     306  JOB      2 TI=723
1943 TUS     T    I  INTERRUPT   TASK     309  JOB      2 TI=724
1943 TUS     T X     EXECUTING   TASK     306  JOB      2 TI=723
1943 TUS     T   W   MSG WAIT    TASK     306  JOB      2 TI=723
1943 TUS     T X     EXECUTING   TASK     309  JOB      2 TI=724
1943 TUS MS          START  52   TASK     306  JOB      2 TI=723 LENGTH  RATE
                     PATH  70001        12       60011                4    60
1943 TUS M E         END    52   TASK     306  JOB      2 TI=723
1943 TUS     T    I  INTERRUPT   TASK     309  JOB      2 TI=724
1943 TUS     T X     EXECUTING   TASK     306  JOB      2 TI=723
1943 TUS     T   W   MSG WAIT    TASK     306  JOB      2 TI=723
1943 TUS     T X     EXECUTING   TASK     309  JOB      2 TI=724
1943 TUS MS          START  11   TASK     306  JOB      2 TI=723 LENGTH  RATE
                     PATH  60011        12       70001               32    60
1943 TUS M E         END    11   TASK     306  JOB      2 TI=723
1943 TUS MS          START  10   TASK     306  JOB      2 TI=723 LENGTH  RATE
                     PATH  70001        11       60010                2    60
1943 TUS M E         END    10   TASK     306  JOB      2 TI=723
1943 TUS     T    I  INTERRUPT   TASK     309  JOB      2 TI=724
1943 TUS     T X     EXECUTING   TASK     306  JOB      2 TI=723
1943 TUS     T   W   MSG WAIT    TASK     306  JOB      2 TI=723
1943 TUS     T X     EXECUTING   TASK     309  JOB      2 TI=724
1943 TUS MS          START  21   TASK     306  JOB      2 TI=723 LENGTH  RATE
                     PATH  60011        12       70001               18    60
1943 TUS M E         END    21   TASK     306  JOB      2 TI=723
1943 TUS MS          START  20   TASK     306  JOB      2 TI=723 LENGTH  RATE
                     PATH  70001        11       60010                2    60
1943 TUS M E         END    20   TASK     306  JOB      2 TI=723
1943 TUS     T    I  INTERRUPT   TASK     309  JOB      2 TI=724
1943 TUS     T X     EXECUTING   TASK     306  JOB      2 TI=723
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1943 TUS     T   W  MSG WAIT   TASK     306  JOB      2 TI=723
1943 TUS     T X    EXECUTING  TASK     309  JOB      2 TI=724
1943 TUS MS         START  52  TASK     306  JOB      2 TI=723 LENGTH  RATE
                    PATH  70001         11       60010              4    60
1943 TUS M E        END    52  TASK     306  JOB      2 TI=723
1943 TUS     T    I INTERRUPT TASK     309  JOB      2 TI=724
1943 TUS     T X    EXECUTING  TASK     306  JOB      2 TI=723
1943 TUS     T   W  MSG WAIT   TASK     306  JOB      2 TI=723
1943 TUS     T X    EXECUTING  TASK     309  JOB      2 TI=724
1943 TUS MS         START  11  TASK     306  JOB      2 TI=723 LENGTH  RATE
                    PATH  60010         11       70001              32    60
1943 TUS M E        END    11  TASK     306  JOB      2 TI=723
1943 TUS MS         START  10  TASK     306  JOB      2 TI=723 LENGTH  RATE
                    PATH  70001         10       60009              2    60
1943 TUS M E        END    10  TASK     306  JOB      2 TI=723
1943 TUS MS         START  21  TASK     306  JOB      2 TI=723 LENGTH  RATE
                    PATH  60010         11       70001              18    60
1943 TUS M E        END    21  TASK     306  JOB      2 TI=723
1943 TUS MS         START  20  TASK     306  JOB      2 TI=723 LENGTH  RATE
                    PATH  70001         10       60009              2    60
1943 TUS M E        END    20  TASK     306  JOB      2 TI=723
1943 TUS MS         START  52  TASK     306  JOB      2 TI=723 LENGTH  RATE
                    PATH  70001         10       60009              4    60
1943 TUS M E        END    52  TASK     306  JOB      2 TI=723
1943 TUS MS         START  11  TASK     306  JOB      2 TI=723 LENGTH  RATE
                    PATH  60009         10       70001              32    60
1943 TUS M E        END    11  TASK     306  JOB      2 TI=723
1943 TUS MS         START  21  TASK     306  JOB      2 TI=723 LENGTH  RATE
                    PATH  60009         10       70001              18    60
1943 TUS M E        END    21  TASK     306  JOB      2 TI=723
1943 TUS     T  E   END        TASK     306  JOB      2 TI=723
1944 TUS M E        END    29  TASK     307  JOB      5 TI=759
1944 TUS M E        END    29  TASK     307  JOB      5 TI=759
1944 TUS M E        END    29  TASK     307  JOB      5 TI=759
1944 TUS M E        END    28  TASK     307  JOB      5 TI=759
1944 TUS     T  E   END        TASK     309  JOB      2 TI=724
1944 TUS     T X    EXECUTING  TASK     181  JOB      3 TI=742
1944 TUS MS         START  28  TASK     307  JOB      5 TI=759 LENGTH  RATE
                    PATH  70003          1       70001            256    60
1944 TUS MS         START  28  TASK     307  JOB      5 TI=759 LENGTH  RATE
                    PATH  70002          2       70001            256    60
1944 TUS MS         START  34  TASK     181  JOB      3 TI=742 LENGTH  RATE
                    PATH  70001         14       70013              2    60
1944 TUS M E        END    34  TASK     181  JOB      3 TI=742
1944 TUS MS         START  61  TASK     181  JOB      3 TI=742 LENGTH  RATE
                    PATH  70001         14       70011              4    60
1944 TUS M E        END    61  TASK     181  JOB      3 TI=742
1944 TUS MS         START  50  TASK     181  JOB      3 TI=742 LENGTH  RATE
                    PATH  70001         12       60011              8    60
1944 TUS M E        END    50  TASK     181  JOB      3 TI=742
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1944 TUS MS       START  62  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       14       70012              4    60
1944 TUS M E      END    62  TASK    181  JOB      3 TI=742
1944 TUS MS       START  63  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       14       70013              4    60
1944 TUS M E      END    63  TASK    181  JOB      3 TI=742
1944 TUS MS       START  34  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       14       70012              2    60
1944 TUS M E      END    34  TASK    181  JOB      3 TI=742
1944 TUS MS       START  35  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70013       14       70001             64    60
1944 TUS MS       START  50  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       10       60009              8    60
1944 TUS M E      END    50  TASK    181  JOB      3 TI=742
1944 TUS MS       START  34  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       15       70011              2    60
1944 TUS M E      END    34  TASK    181  JOB      3 TI=742
1944 TUS MS       START  35  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70012       15       70001             64    60
1944 TUS MS       START  35  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70011       16       70001             64    60
1945 TUS M E      END    35  TASK    181  JOB      3 TI=742
1945 TUS M E      END    35  TASK    181  JOB      3 TI=742
1945 TUS M E      END    35  TASK    181  JOB      3 TI=742
1945 TUS    T  E  END        TASK    181  JOB      3 TI=742
1945 TUS    T X   EXECUTING  TASK    176  JOB      2 TI=716
1948 TUS M E      END    58  TASK    307  JOB      5 TI=759
1948 TUS M E      END    28  TASK    307  JOB      5 TI=759
1948 TUS M E      END    28  TASK    307  JOB      5 TI=759
1948 TUS    T  E  END        TASK    307  JOB      5 TI=759
1954 TUS    T  E  END        TASK    176  JOB      2 TI=716
1954 TUS    T X   EXECUTING  TASK     62  JOB      3 TI=734
1954 TUS MS       START  64  TASK     62  JOB      3 TI=734 LENGTH  RATE
                  PATH  70001       10       60013             10    60
1954 TUS M E      END    64  TASK     62  JOB      3 TI=734
1954 TUS MS       START  65  TASK     62  JOB      3 TI=734 LENGTH  RATE
                  PATH  70001       11       60014             10    60
1954 TUS M E      END    65  TASK     62  JOB      3 TI=734
1954 TUS MS       START  66  TASK     62  JOB      3 TI=734 LENGTH  RATE
                  PATH  70001       12       60015             10    60
1954 TUS M E      END    66  TASK     62  JOB      3 TI=734
1954 TUS MS       START  67  TASK     62  JOB      3 TI=734 LENGTH  RATE
                  PATH  70001       13       60016             10    60
1954 TUS M E      END    67  TASK     62  JOB      3 TI=734
1955 TUS    T  E  END        TASK     62  JOB      3 TI=734
1955 TUS    T X   EXECUTING  TASK     60  JOB      3 TI=733
1955 TUS MS       START  64  TASK     60  JOB      3 TI=733 LENGTH  RATE
                  PATH  70001       10       60013             14    60
1955 TUS M E      END    64  TASK     60  JOB      3 TI=733
1955 TUS MS       START  65  TASK     60  JOB      3 TI=733 LENGTH  RATE
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                    PATH  70001      11       60014              14    60
1955 TUS M E        END    65  TASK     60  JOB      3 TI=733
1955 TUS MS         START  66  TASK     60  JOB      3 TI=733 LENGTH  RATE
                    PATH  70001      12       60015              14    60
1955 TUS M E        END    66  TASK     60  JOB      3 TI=733
1955 TUS MS         START  67  TASK     60  JOB      3 TI=733 LENGTH  RATE
                    PATH  70001      13       60016              14    60
1955 TUS M E        END    67  TASK     60  JOB      3 TI=733
1956 TUS    T  E    END        TASK     60  JOB      3 TI=733
1956 TUS    T X     EXECUTING  TASK     41  JOB      3 TI=727
1956 TUS    T   W   MSG WAIT   TASK     41  JOB      3 TI=727
1956 TUS    T X     EXECUTING  TASK     40  JOB      3 TI=726
1956 TUS MS         START  22  TASK     41  JOB      3 TI=727 LENGTH  RATE
                    PATH  70001      12       60015               2    60
1956 TUS M E        END    22  TASK     41  JOB      3 TI=727
1956 TUS    T    I  INTERRUPT  TASK     40  JOB      3 TI=726
1956 TUS    T X     EXECUTING  TASK     41  JOB      3 TI=727
1956 TUS    T   W   MSG WAIT   TASK     41  JOB      3 TI=727
1956 TUS    T X     EXECUTING  TASK     40  JOB      3 TI=726
1956 TUS MS         START  22  TASK     40  JOB      3 TI=726 LENGTH  RATE
                    PATH  70001      12       60015               2    60
1956 TUS M E        END    22  TASK     40  JOB      3 TI=726
1956 TUS MS         START  23  TASK     41  JOB      3 TI=727 LENGTH  RATE
                    PATH  60015      12       70001               8    60
1956 TUS M E        END    23  TASK     41  JOB      3 TI=727
1956 TUS MS         START  22  TASK     41  JOB      3 TI=727 LENGTH  RATE
                    PATH  70001      11       60014               2    60
1956 TUS M E        END    22  TASK     41  JOB      3 TI=727
1956 TUS    T    I  INTERRUPT  TASK     40  JOB      3 TI=726
1956 TUS    T X     EXECUTING  TASK     41  JOB      3 TI=727
1956 TUS    T   W   MSG WAIT   TASK     41  JOB      3 TI=727
1956 TUS    T X     EXECUTING  TASK     40  JOB      3 TI=726
1956 TUS    T   W   MSG WAIT   TASK     40  JOB      3 TI=726
1956 TUS    T X     EXECUTING  TASK     50  JOB      3 TI=731
1956 TUS MS         START  22  TASK     40  JOB      3 TI=726 LENGTH  RATE
                    PATH  70001      11       60014               2    60
1956 TUS M E        END    22  TASK     40  JOB      3 TI=726
1956 TUS    T    I  INTERRUPT  TASK     50  JOB      3 TI=731
1956 TUS    T X     EXECUTING  TASK     40  JOB      3 TI=726
1956 TUS    T   W   MSG WAIT   TASK     40  JOB      3 TI=726
1956 TUS    T X     EXECUTING  TASK     50  JOB      3 TI=731
1956 TUS MS         START  23  TASK     40  JOB      3 TI=726 LENGTH  RATE
                    PATH  60015      12       70001               8    60
1956 TUS M E        END    23  TASK     40  JOB      3 TI=726
1956 TUS MS         START  23  TASK     41  JOB      3 TI=727 LENGTH  RATE
                    PATH  60014      11       70001               8    60
1956 TUS M E        END    23  TASK     41  JOB      3 TI=727
1956 TUS MS         START  22  TASK     41  JOB      3 TI=727 LENGTH  RATE
                    PATH  70001      10       60013               2    60
1956 TUS M E        END    22  TASK     41  JOB      3 TI=727
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1956 TUS MS       START  53  TASK     50  JOB      3 TI=731 LENGTH  RATE
                  PATH  70001      13       60016              14    60
1956 TUS M E      END    53  TASK     50  JOB      3 TI=731
1956 TUS MS       START  23  TASK     40  JOB      3 TI=726 LENGTH  RATE
                  PATH  60014      11       70001               8    60
1956 TUS M E      END    23  TASK     40  JOB      3 TI=726
1956 TUS MS       START  22  TASK     40  JOB      3 TI=726 LENGTH  RATE
                  PATH  70001      10       60013               2    60
1956 TUS M E      END    22  TASK     40  JOB      3 TI=726
1956 TUS MS       START  23  TASK     41  JOB      3 TI=727 LENGTH  RATE
                  PATH  60013      10       70001               8    60
1956 TUS M E      END    23  TASK     41  JOB      3 TI=727
1956 TUS    T  E  END         TASK     41  JOB      3 TI=727
1956 TUS MS       START  53  TASK     50  JOB      3 TI=731 LENGTH  RATE
                  PATH  70001      12       60015              14    60
1956 TUS M E      END    53  TASK     50  JOB      3 TI=731
1956 TUS MS       START  23  TASK     40  JOB      3 TI=726 LENGTH  RATE
                  PATH  60013      10       70001               8    60
1956 TUS M E      END    23  TASK     40  JOB      3 TI=726
1956 TUS    T  E  END         TASK     40  JOB      3 TI=726
1956 TUS MS       START  53  TASK     50  JOB      3 TI=731 LENGTH  RATE
                  PATH  70001      11       60014              14    60
1956 TUS M E      END    53  TASK     50  JOB      3 TI=731
1956 TUS MS       START  53  TASK     50  JOB      3 TI=731 LENGTH  RATE
                  PATH  70001      10       60013              14    60
1956 TUS M E      END    53  TASK     50  JOB      3 TI=731
1957 TUS    T  E  END         TASK     50  JOB      3 TI=731
1957 TUS    T X   EXECUTING   TASK    203  JOB      2 TI=720
1957 TUS MS       START  44  TASK    203  JOB      2 TI=720 LENGTH  RATE
                  PATH  70001      22       60033               2    60
1957 TUS M E      END    44  TASK    203  JOB      2 TI=720
1957 TUS MS       START  44  TASK    203  JOB      2 TI=720 LENGTH  RATE
                  PATH  70001      22       60032               2    60
1957 TUS M E      END    44  TASK    203  JOB      2 TI=720
1957 TUS MS       START  45  TASK    203  JOB      2 TI=720 LENGTH  RATE
                  PATH  60033      22       70001              48    60
1957 TUS M E      END    45  TASK    203  JOB      2 TI=720
1957 TUS MS       START  44  TASK    203  JOB      2 TI=720 LENGTH  RATE
                  PATH  70001      22       60031               2    60
1957 TUS M E      END    44  TASK    203  JOB      2 TI=720
1957 TUS MS       START  45  TASK    203  JOB      2 TI=720 LENGTH  RATE
                  PATH  60032      22       70001              38    60
1957 TUS M E      END    45  TASK    203  JOB      2 TI=720
1957 TUS MS       START  44  TASK    203  JOB      2 TI=720 LENGTH  RATE
                  PATH  70001      22       60030               2    60
1957 TUS M E      END    44  TASK    203  JOB      2 TI=720
1957 TUS MS       START  45  TASK    203  JOB      2 TI=720 LENGTH  RATE
                  PATH  60031      22       70001              42    60
1957 TUS M E      END    45  TASK    203  JOB      2 TI=720
1957 TUS MS       START  45  TASK    203  JOB      2 TI=720 LENGTH  RATE
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                PATH  60030      22       70001              32    60
1957 TUS M E    END    45 TASK    203 JOB      2 TI=720
1958 TUS    T E END       TASK    203 JOB      2 TI=720
1958 TUS    T X EXECUTING TASK     91 JOB      4 TI=747
1958 TUS MS     START   6 TASK     91 JOB      4 TI=747 LENGTH  RATE
                PATH  70001      12       60011              2    60
1958 TUS M E    END     6 TASK     91 JOB      4 TI=747
1958 TUS MS     START  22 TASK     91 JOB      4 TI=747 LENGTH  RATE
                PATH  70001      12       60015              2    60
1958 TUS M E    END    22 TASK     91 JOB      4 TI=747
1958 TUS MS     START  38 TASK     91 JOB      4 TI=747 LENGTH  RATE
                PATH  70001      13       60012              2    60
1958 TUS M E    END    38 TASK     91 JOB      4 TI=747
1958 TUS MS     START  46 TASK     91 JOB      4 TI=747 LENGTH  RATE
                PATH  70001      13       60016              2    60
1958 TUS M E    END    46 TASK     91 JOB      4 TI=747
1958 TUS MS     START   6 TASK     91 JOB      4 TI=747 LENGTH  RATE
                PATH  70001      11       60010              2    60
1958 TUS M E    END     6 TASK     91 JOB      4 TI=747
1958 TUS MS     START   7 TASK     91 JOB      4 TI=747 LENGTH  RATE
                PATH  60011      12       70001              2    60
1958 TUS M E    END     7 TASK     91 JOB      4 TI=747
1958 TUS MS     START  22 TASK     91 JOB      4 TI=747 LENGTH  RATE
                PATH  70001      11       60014              2    60
1958 TUS M E    END    22 TASK     91 JOB      4 TI=747
1958 TUS MS     START  23 TASK     91 JOB      4 TI=747 LENGTH  RATE
                PATH  60015      12       70001              2    60
1958 TUS M E    END    23 TASK     91 JOB      4 TI=747
1958 TUS MS     START  38 TASK     91 JOB      4 TI=747 LENGTH  RATE
                PATH  70001      12       60011              2    60
1958 TUS M E    END    38 TASK     91 JOB      4 TI=747
1958 TUS MS     START  39 TASK     91 JOB      4 TI=747 LENGTH  RATE
                PATH  60012      13       70001             20    60
1958 TUS M E    END    39 TASK     91 JOB      4 TI=747
1958 TUS MS     START  46 TASK     91 JOB      4 TI=747 LENGTH  RATE
                PATH  70001      12       60015              2    60
1958 TUS M E    END    46 TASK     91 JOB      4 TI=747
1958 TUS MS     START  47 TASK     91 JOB      4 TI=747 LENGTH  RATE
                PATH  60016      13       70001              4    60
1958 TUS M E    END    47 TASK     91 JOB      4 TI=747
1958 TUS MS     START   6 TASK     91 JOB      4 TI=747 LENGTH  RATE
                PATH  70001      10       60009              2    60
1958 TUS M E    END     6 TASK     91 JOB      4 TI=747
1958 TUS MS     START   7 TASK     91 JOB      4 TI=747 LENGTH  RATE
                PATH  60010      11       70001              2    60
1958 TUS M E    END     7 TASK     91 JOB      4 TI=747
1958 TUS MS     START  22 TASK     91 JOB      4 TI=747 LENGTH  RATE
                PATH  70001      10       60013              2    60
1958 TUS M E    END    22 TASK     91 JOB      4 TI=747
1958 TUS MS     START  23 TASK     91 JOB      4 TI=747 LENGTH  RATE
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                    PATH  60014       11        70001                2    60
1958 TUS M E        END    23  TASK     91  JOB      4 TI=747
1958 TUS MS         START  38  TASK     91  JOB      4 TI=747 LENGTH  RATE
                    PATH  70001       11        60010                2    60
1958 TUS M E        END    38  TASK     91  JOB      4 TI=747
1958 TUS MS         START  39  TASK     91  JOB      4 TI=747 LENGTH  RATE
                    PATH  60011       12        70001               32    60
1958 TUS M E        END    39  TASK     91  JOB      4 TI=747
1958 TUS MS         START  46  TASK     91  JOB      4 TI=747 LENGTH  RATE
                    PATH  70001       11        60014                2    60
1958 TUS M E        END    46  TASK     91  JOB      4 TI=747
1958 TUS MS         START  47  TASK     91  JOB      4 TI=747 LENGTH  RATE
                    PATH  60015       12        70001                4    60
1958 TUS M E        END    47  TASK     91  JOB      4 TI=747
1958 TUS MS         START   7  TASK     91  JOB      4 TI=747 LENGTH  RATE
                    PATH  60009       10        70001                2    60
1958 TUS M E        END     7  TASK     91  JOB      4 TI=747
1958 TUS MS         START  23  TASK     91  JOB      4 TI=747 LENGTH  RATE
                    PATH  60013       10        70001                2    60
1958 TUS M E        END    23  TASK     91  JOB      4 TI=747
1958 TUS MS         START  38  TASK     91  JOB      4 TI=747 LENGTH  RATE
                    PATH  70001       10        60009                2    60
1958 TUS M E        END    38  TASK     91  JOB      4 TI=747
1958 TUS MS         START  39  TASK     91  JOB      4 TI=747 LENGTH  RATE
                    PATH  60010       11        70001               20    60
1958 TUS M E        END    39  TASK     91  JOB      4 TI=747
1958 TUS MS         START  46  TASK     91  JOB      4 TI=747 LENGTH  RATE
                    PATH  70001       10        60013                2    60
1958 TUS M E        END    46  TASK     91  JOB      4 TI=747
1958 TUS MS         START  47  TASK     91  JOB      4 TI=747 LENGTH  RATE
                    PATH  60014       11        70001                4    60
1958 TUS M E        END    47  TASK     91  JOB      4 TI=747
1958 TUS MS         START  39  TASK     91  JOB      4 TI=747 LENGTH  RATE
                    PATH  60009       10        70001               32    60
1958 TUS M E        END    39  TASK     91  JOB      4 TI=747
1958 TUS MS         START  47  TASK     91  JOB      4 TI=747 LENGTH  RATE
                    PATH  60013       10        70001                4    60
1958 TUS M E        END    47  TASK     91  JOB      4 TI=747
1960 TUS    T  E    END        TASK     91  JOB      4 TI=747
1960 TUS    T X     EXECUTING  TASK     52  JOB      2 TI=712
1960 TUS MS         START  22  TASK     52  JOB      2 TI=712 LENGTH  RATE
                    PATH  70001       12        60015                2    60
1960 TUS M E        END    22  TASK     52  JOB      2 TI=712
1960 TUS MS         START  22  TASK     52  JOB      2 TI=712 LENGTH  RATE
                    PATH  70001       11        60014                2    60
1960 TUS M E        END    22  TASK     52  JOB      2 TI=712
1960 TUS MS         START  23  TASK     52  JOB      2 TI=712 LENGTH  RATE
                    PATH  60015       12        70001                4    60
1960 TUS M E        END    23  TASK     52  JOB      2 TI=712
1960 TUS MS         START  22  TASK     52  JOB      2 TI=712 LENGTH  RATE
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                PATH  70001      10       60013              2    60
1960 TUS M E    END    22  TASK    52  JOB      2 TI=712
1960 TUS MS     START  23  TASK    52  JOB      2 TI=712 LENGTH  RATE
                PATH  60014      11       70001              4    60
1960 TUS M E    END    23  TASK    52  JOB      2 TI=712
1960 TUS MS     START  23  TASK    52  JOB      2 TI=712 LENGTH  RATE
                PATH  60013      10       70001              4    60
1960 TUS M E    END    23  TASK    52  JOB      2 TI=712
1961 TUS    T  E END        TASK    52  JOB      2 TI=712
1961 TUS    T X EXECUTING   TASK   120  JOB      3 TI=740
1961 TUS MS     START  22  TASK   120  JOB      3 TI=740 LENGTH  RATE
                PATH  70001      12       60015              2    60
1961 TUS M E    END    22  TASK   120  JOB      3 TI=740
1961 TUS MS     START  46  TASK   120  JOB      3 TI=740 LENGTH  RATE
                PATH  70001      13       60016              2    60
1961 TUS M E    END    46  TASK   120  JOB      3 TI=740
1961 TUS MS     START  22  TASK   120  JOB      3 TI=740 LENGTH  RATE
                PATH  70001      11       60014              2    60
1961 TUS M E    END    22  TASK   120  JOB      3 TI=740
1961 TUS MS     START  23  TASK   120  JOB      3 TI=740 LENGXH  RATE
                PATH  60015      12       70001              8    60
1961 TUS M E    END    23  TASK   120  JOB      3 TI=740
1961 TUS MS     START  46  TASK   120  JOB      3 TI=740 LENGTH  RATE
                PATH  70001      12       60015              2    60
1961 TUS M E    END    46  TASK   120  JOB      3 TI=740
1961 TUS MS     START  47  TASK   120  JOB      3 TI=740 LENGTH  RATE
                PATH  60016      13       70001             ___2  60
1961 TUS M E    END    47  TASK   120  JOB      3 TI=740
1961 TUS MS     START  22  TASK   120  JOB      3 TI=740 LENGTH  RATE
                PATH  70001      10       60013              2    60
1961 TUS M E    END    22  TASK   120  JOB      3 TI=740
1961 TUS MS     START  23  TASK   120  JOB      3 TI=740 LENGTH  RATE
                PATH  60014      11       70001              8    60
1961 TUS M E    END    23  TASK   120  JOB      3 TI=740
1961 TUS MS     START  46  TASK   120  JOB      3 TI=740 LENGTH  RATE
                PATH  70001      11       60014              2    60
1961 TUS M E    END    46  TASK   120  JOB      3 TI=740
1961 TUS MS     START  47  TASK   120  JOB      3 TI=740 LENGTH  RATE
                PATH  60015      12       70001              2    60
1961 TUS M E    END    47  TASK   120  JOB      3 TI=740
1961 TUS MS     START  23  TASK   120  JOB      3 TI=740 LENGTH  RATE
                PATH  60013      10       70001              8    60
1961 TUS M E    END    23  TASK   120  JOB      3 TI=740
1961 TUS MS     START  46  TASK   120  JOB      3 TI=740 LENGTH  RATE
                PATH  70001      10       60013              2    60
1961 TUS M E    END    46  TASK   120  JOB      3 TI=740
1961 TUS MS     START  47  TASK   120  JOB      3 TI=740 LENGTH  RATE
                PATH  60014      11       70001              2    60
1961 TUS M E    END    47  TASK   120  JOB      3 TI=740
1961 TUS MS     START  47  TASK   120  JOB      3 TI=740 LENGTH  RATE
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                    PATH  60013      10       70001                2    60
1961 TUS M E        END    47  TASK    120  JOB      3 TI=740
1962 TUS    T  E    END        TASK    120  JOB      3 TI=740
1962 TUS    T X     EXECUTING  TASK    119  JOB      3 TI=739
1962 TUS MS         START  46  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  70001      13       60016                2    60
1962 TUS M E        END    46  TASK    119  JOB      3 TI=739
1962 TUS MS         START  46  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  70001      12       60015                2    60
1962 TUS M E        END    46  TASK    119  JOB      3 TI=739
1962 TUS MS         START  47  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  60016      13       70001                2    60
1962 TUS M E        END    47  TASK    119  JOB      3 TI=739
1962 TUS MS         START  46  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  70001      11       60014                2    60
1962 TUS M E        END    46  TASK    119  JOB      3 TI=739
1962 TUS MS         START  47  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  60015      12       70001                2    60
1962 TUS M E        END    47  TASK    119  JOB      3 TI=739
1962 TUS MS         START  46  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  70001      10       60013                2    60
1962 TUS M E        END    46  TASK    119  JOB      3 TI=739
1962 TUS MS         START  47  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  60014      11       70001                2    60
1962 TUS M E        END    47  TASK    119  JOB      3 TI=739
1962 TUS MS         START  47  TASK    119  JOB      3 TI=739 LENGTH  RATE
                    PATH  60013      10       70001                2    60
1962 TUS M E        END    47  TASK    119  JOB      3 TI=739
1963 TUS    T  E    END        TASK    119  JOB      3 TI=739
1963 TUS    T X     EXECUTING  TASK     42  JOB      3 TI=728
1963 TUS MS         START   6  TASK     42  JOB      3 TI=728 LENGTH  RATE
                    PATH  70001      12       60011                2    60
1963 TUS M E        END     6  TASK     42  JOB      3 TI=728
1963 TUS MS         START   6  TASK     42  JOB      3 TI=728 LENGTH  RATE
                    PATH  70001      11       60010                2    60
1963 TUS M E        END     6  TASK     42  JOB      3 TI=728
1963 TUS MS         START   7  TASK     42  JOB      3 TI=728 LENGTH  RATE
                    PATH  60011      12       70001                4    60
1963 TUS M E        END     7  TASK     42  JOB      3 TI=728
1963 TUS MS         START   6  TASK     42  JOB      3 TI=728 LENGTH  RATE
                    PATH  70001      10       60009                2    60
1963 TUS M E        END     6  TASK     42  JOB      3 TI=728
1963 TUS MS         START   7  TASK     42  JOB      3 TI=728 LENGTH  RATE
                    PATH  60010      11       70001                4    60
1963 TUS M E        END     7  TASK     42  JOB      3 TI=728
1963 TUS MS         START   7  TASK     42  JOB      3 TI=728 LENGTH  RATE
                    PATH  60009      10       70001                4    60
1963 TUS M E        END     7  TASK     42  JOB      3 TI=728
1964 TUS    T  E    END        TASK     42  JOB      3 TI=728
1964 TUS    T X     EXECUTING  TASK    333  JOB      5 TI=761
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1966 TUS    T  E   END          TASK     333  JOB      5 TI=761
1966 TUS    T X    EXECUTING    TASK      49  JOB      3 TI=730
1966 TUS MS        START  46    TASK      49  JOB      3 TI=730 LENGTH  RATE
                   PATH   70001         13       60016              2    60
1966 TUS M E       END    46    TASK      49  JOB      3 TI=730
1966 TUS MS        START  46    TASK      49  JOB      3 TI=730 LENGTH  RATE
                   PATH   70001         12       60015              2    60
1966 TUS M E       END    46    TASK      49  JOB      3 TI=730
1966 TUS MS        START  47    TASK      49  JOB      3 TI=730 LENGTH  RATE
                   PATH   60016         13       70001              2    60
1966 TUS M E       END    47    TASK      49  JOB      3 TI=730
1966 TUS MS        START  46    TASK      49  JOB      3 TI=730 LENGTH  RATE
                   PATH   70001         11       60014              2    60
1966 TUS M E       END    46    TASK      49  JOB      3 TI=730
1966 TUS MS        START  47    TASK      49  JOB      3 TI=730 LENGTH  RATE
                   PATH   60015         12       70001              2    60
1966 TUS M E       END    47    TASK      49  JOB      3 TI=730
1966 TUS MS        START  46    TASK      49  JOB      3 TI=730 LENGTH  RATE
                   PATH   70001         10       60013              2    60
1966 TUS M E       END    46    TASK      49  JOB      3 TI=730
1966 TUS MS        START  47    TASK      49  JOB      3 TI=730 LENGTH  RATE
                   PATH   60014         11       70001              2    60
1966 TUS M E       END    47    TASK      49  JOB      3 TI=730
1966 TUS MS        START  47    TASK      49  JOB      3 TI=730 LENGTH  RATE
                   PATH   60013         10       70001              2    60
1966 TUS M E       END    47    TASK      49  JOB      3 TI=730
1967 TUS    T  E   END          TASK      49  JOB      3 TI=730
1967 TUS    T X    EXECUTING    TASK      19  JOB      2 TI=710
1967 TUS    T  E   END          TASK      19  JOB      2 TI=710
1967 TUS    T X    EXECUTING    TASK      15  JOB      2 TI=709
1980 TUS    TG     GO FOR       TASK     180
1980 TUS    T    I INTERRUPT    TASK      15  JOB      2 TI=709
1980 TUS    TG     GO FOR       TASK     114
1980 TUS    T    I INTERRUPT    TASK     180  JOB      2 TI=717
1980 TUS    TG     GO FOR       TASK     307
1980 TUS    T    I INTERRUPT    TASK     114  JOB      4 TI=751
1980 TUS    TG     GO FOR       TASK     181
1980 TUS    T X    EXECUTING    TASK     307  JOB      5 TI=759
1980 TUS    TG     GO FOR       TASK     306
1980 TUS MS        START  29    TASK     307  JOB      5 TI=759 LENGTH  RATE
                   PATH   70001          1       70004            256    60
1980 TUS    TG     GO FOR       TASK     176
1980 TUS MS        START  29    TASK     307  JOB      5 TI=759 LENGTH  RATE
                   PATH   70001          3       70003            256    60
1980 TUS    TG     GO FOR       TASK     309
1980 TUS MS        START  29    TASK     307  JOB      5 TI=759 LENGTH  RATE
                   PATH   70001          2       70002            256    60
1980 TUS    TG     GO FOR       TASK      62
1980 TUS MS        START  28    TASK     307  JOB      5 TI=759 LENGTH  RATE
                   PATH   70004          4       70001            256    60
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1980 TUS    TG      GO FOR      TASK      40
1980 TUS MS         START  58   TASK     307  JOB      5 TI=759 LENGTH  RATE
                    PATH  70001        24        60095              512    60
1980 TUS    TG      GO FOR      TASK      60
1980 TUS    TG      GO FOR      TASK      91
1980 TUS    TG      GO FOR      TASK      41
1980 TUS    TG      GO FOR      TASK      50
1980 TUS    TG      GO FOR      TASK     203
1980 TUS    TG      GO FOR      TASK      52
1980 TUS    TG      GO FOR      TASK     120
1980 TUS    TG      GO FOR      TASK     119
1980 TUS    TG      GO FOR      TASK      42
1980 TUS    TG      GO FOR      TASK     333
1983 TUS    T   W   MSG WAIT    TASK     307  JOB      5 TI=759
1983 TUS    T X     EXECUTING   TASK     306  JOB      2 TI=723
1983 TUS    T   W   MSG WAIT    TASK     306  JOB      2 TI=723
1983 TUS    T X     EXECUTING   TASK     309  JOB      2 TI=724
1983 TUS MS         START  10   TASK     306  JOB      2 TI=723 LENGTH  RATE
                    PATH  70001        12        60011              2    60
1983 TUS M E        END    10   TASK     306  JOB      2 TI=723
1983 TUS    T    I  INTERRUPT   TASK     309  JOB      2 TI=724
1983 TUS    T X     EXECUTING   TASK     306  JOB      2 TI=723
1983 TUS    T   W   MSG WAIT    TASK     306  JOB      2 TI=723
1983 TUS    T X     EXECUTING   TASK     309  JOB      2 TI=724
1983 TUS MS         START  20   TASK     306  JOB      2 TI=723 LENGTH  RATE
                    PATH  70001        12        60011              2    60
1983 TUS M E        END    20   TASK     306  JOB      2 TI=723
1983 TUS    T    I  INTERRUPT   TASK     309  JOB      2 TI=724
1983 TUS    T X     EXECUTING   TASK     306  JOB      2 TI=723
1983 TUS    T   W   MSG WAIT    TASK     306  JOB      2 TI=723
1983 TUS    T X     EXECUTING   TASK     309  JOB      2 TI=724
1983 TUS MS         START  52   TASK     306  JOB      2 TI=723 LENGTH  RATE
                    PATH  70001        12        60011              4    60
1983 TUS M E        END    52   TASK     306  JOB      2 TI=723
1983 TUS    T    I  INTERRUPT   TASK     309  JOB      2 TI=724
1983 TUS    T X     EXECUTING   TASK     306  JOB      2 TI=723
1983 TUS    T   W   MSG WAIT    TASK     306  JOB      2 TI=723
1983 TUS    T X     EXECUTING   TASK     309  JOB      2 TI=724
1983 TUS MS         START  11   TASK     306  JOB      2 TI=723 LENGTH  RATE
                    PATH  60011        12        70001              32    60
1983 TUS M E        END    11   TASK     306  JOB      2 TI=723
1983 TUS MS         START  10   TASK     306  JOB      2 TI=723 LENGTH  RATE
                    PATH  70001        11        60010              2    60
1983 TUS M E        END    10   TASK     306  JOB      2 TI=723
1983 TUS    T    I  INTERRUPT   TASK     309  JOB      2 TI=724
1983 TUS    T X     EXECUTING   TASK     306  JOB      2 TI=723
1983 TUS    T   W   MSG WAIT    TASK     306  JOB      2 TI=723
1983 TUS    T X     EXECUTING   TASK     309  JOB      2 TI=724
1983 TUS MS         START  21   TASK     306  JOB      2 TI=723 LENGTH  RATE
                    PATH  60011        12        70001              18    60
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1983 TUS M E       END    21  TASK     306  JOB      2 TI=723
1983 TUS MS        START  20  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  70001        11       60010              2    60
1983 TUS M E       END    20  TASK     306  JOB      2 TI=723
1983 TUS    T    I INTERRUPT TASK     309  JOB      2 TI=724
1983 TUS    T X   EXECUTING TASK     306  JOB      2 TI=723
1983 TUS    T   W MSG WAIT  TASK     306  JOB      2 TI=723
1983 TUS    T X   EXECUTING TASK     309  JOB      2 TI=724
1983 TUS MS        START  52  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  70001        11       60010              4    60
1983 TUS M E       END    52  TASK     306  JOB      2 TI=723
1983 TUS    T    I INTERRUPT TASK     309  JOB      2 TI=724
1983 TUS    T X   EXECUTING TASK     306  JOB      2 TI=723
1983 TUS    T   W MSG WAIT  TASK     306  JOB      2 TI=723
1983 TUS    T X   EXECUTING TASK     309  JOB      2 TI=724
1983 TUS MS        START  11  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  60010        11       70001             32    60
1983 TUS M E       END    11  TASK     306  JOB      2 TI=723
1983 TUS MS        START  10  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  70001        10       60009              2    60
1983 TUS M E       END    10  TASK     306  JOB      2 TI=723
1983 TUS MS        START  21  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  60010        11       70001             18    60
1983 TUS M E       END    21  TASK     306  JOB      2 TI=723
1983 TUS MS        START  20  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  70001        10       60009              2    60
1983 TUS M E       END    20  TASK     306  JOB      2 TI=723
1983 TUS MS        START  52  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  70001        10       60009              4    60
1983 TUS M E       END    52  TASK     306  JOB      2 TI=723
1983 TUS MS        START  11  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  60009        10       70001             32    60
1983 TUS M E       END    11  TASK     306  JOB      2 TI=723
1983 TUS MS        START  21  TASK     306  JOB      2 TI=723 LENGTH  RATE
                   PATH  60009        10       70001             18    60
1983 TUS M E       END    21  TASK     306  JOB      2 TI=723
1983 TUS    T  E   END        TASK     306  JOB      2 TI=723
1984 TUS M E       END    29  TASK     307  JOB      5 TI=759
1984 TUS M E       END    29  TASK     307  JOB      5 TI=759
1984 TUS M E       END    29  TASK     307  JOB      5 TI=759
1984 TUS M E       END    28  TASK     307  JOB      5 TI=759
1984 TUS    T  E   END        TASK     309  JOB      2 TI=724
1984 TUS    T X   EXECUTING TASK     181  JOB      3 TI=742
1984 TUS MS        START  28  TASK     307  JOB      5 TI=759 LENGTH  RATE
                   PATH  70003         1       70001             256    60
1984 TUS MS        START  28  TASK     307  JOB      5 TI=759 LENGTH  RATE
                   PATH  70002         2       70001             256    60
1984 TUS MS        START  34  TASK     181  JOB      3 TI=742 LENGTH  RATE
                   PATH  70001        14       70013              2    60
1984 TUS M E       END    34  TASK     181  JOB      3 TI=742
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1984 TUS MS       START  61  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       14       70011              4    60
1984 TUS M E      END    61  TASK    181  JOB      3 TI=742
1984 TUS MS       START  62  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       14       70012              4    60
1984 TUS M E      END    62  TASK    181  JOB      3 TI=742
1984 TUS MS       START  63  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       14       70013              4    60
1984 TUS M E      END    63  TASK    181  JOB      3 TI=742
1984 TUS MS       START  50  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       12       60011              8    60
1984 TUS M E      END    50  TASK    181  JOB      3 TI=742
1984 TUS MS       START  34  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       14       70012              2    60
1984 TUS M E      END    34  TASK    181  JOB      3 TI=742
1984 TUS MS       START  35  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70013       14       70001             64    60
1984 TUS MS       START  50  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       10       60009              8    60
1984 TUS M E      END    50  TASK    181  JOB      3 TI=742
1984 TUS MS       START  34  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70001       15       70011              2    60
1984 TUS M E      END    34  TASK    181  JOB      3 TI=742
1984 TUS MS       START  35  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70012       15       70001             64    60
1984 TUS MS       START  35  TASK    181  JOB      3 TI=742 LENGTH  RATE
                  PATH  70011       16       70001             64    60
1985 TUS M E      END    35  TASK    181  JOB      3 TI=742
1985 TUS M E      END    35  TASK    181  JOB      3 TI=742
1985 TUS M E      END    35  TASK    181  JOB      3 TI=742
1985 TUS    T  E  END        TASK    181  JOB      3 TI=742
1985 TUS    T X   EXECUTING  TASK    176  JOB      2 TI=716
1988 TUS M E      END    58  TASK    307  JOB      5 TI=759
1988 TUS M E      END    28  TASK    307  JOB      5 TI=759
1988 TUS M E      END    28  TASK    307  JOB      5 TI=759
1988 TUS    T  E  END        TASK    307  JOB      5 TI=759
1993 TUS    T  E  END        TASK    176  JOB      2 TI=716
1993 TUS    T X   EXECUTING  TASK     62  JOB      3 TI=734
1993 TUS MS       START  64  TASK     62  JOB      3 TI=734 LENGTH  RATE
                  PATH  70001       10       60013             10    60
1993 TUS M E      END    64  TASK     62  JOB      3 TI=734
1993 TUS MS       START  65  TASK     62  JOB      3 TI=734 LENGTH  RATE
                  PATH  70001       11       60014             10    60
1993 TUS M E      END    65  TASK     62  JOB      3 TI=734
1993 TUS MS       START  66  TASK     62  JOB      3 TI=734 LENGTH  RATE
                  PATH  70001       12       60015             10    60
1993 TUS M E      END    66  TASK     62  JOB      3 TI=734
1993 TUS MS       START  67  TASK     62  JOB      3 TI=734 LENGTH  RATE
                  PATH  70001       13       60016             10    60
1993 TUS M E      END    67  TASK     62  JOB      3 TI=734
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1994 TUS    T  E   END        TASK      62  JOB      3 TI=734
1994 TUS    T X    EXECUTING  TASK      60  JOB      3 TI=733
1994 TUS MS        START  64  TASK      60  JOB      3 TI=733 LENGTH  RATE
                   PATH  70001        10       60013              14    60
1994 TUS M E       END    64  TASK      60  JOB      3 TI=733
1994 TUS MS        START  65  TASK      60  JOB      3 TI=733 LENGTH  RATE
                   PATH  70001        11       60014              14    60
1994 TUS M E       END    65  TASK      60  JOB      3 TI=733
1994 TUS MS        START  66  TASK      60  JOB      3 TI=733 LENGTH  RATE
                   PATH  70001        12       60015              14    60
1994 TUS M E       END    66  TASK      60  JOB      3 TI=733
1994 TUS MS        START  67  TASK      60  JOB      3 TI=733 LENGTH  RATE
                   PATH  70001        13       60016              14    60
1994 TUS M E       END    67  TASK      60  JOB      3 TI=733
1996 TUS    T  E   END        TASK      60  JOB      3 TI=733
1996 TUS    T X    EXECUTING  TASK      41  JOB      3 TI=727
1996 TUS MS        START  22  TASK      41  JOB      3 TI=727 LENGTH  RATE
                   PATH  70001        12       60015               2    60
1996 TUS M E       END    22  TASK      41  JOB      3 TI=727
1996 TUS MS        START  22  TASK      41  JOB      3 TI=727 LENGTH  RATE
                   PATH  70001        11       60014               2    60
1996 TUS M E       END    22  TASK      41  JOB      3 TI=727
1996 TUS MS        START  23  TASK      41  JOB      3 TI=727 LENGTH  RATE
                   PATH  60015        12       70001               8    60
1996 TUS M E       END    23  TASK      41  JOB      3 TI=727
1996 TUS MS        START  22  TASK      41  JOB      3 TI=727 LENGTH  RATE
                   PATH  70001        10       60013               2    60
1996 TUS M E       END    22  TASK      41  JOB      3 TI=727
1996 TUS MS        START  23  TASK      41  JOB      3 TI=727 LENGTH  RATE
                   PATH  60014        11       70001               8    60
1996 TUS M E       END    23  TASK      41  JOB      3 TI=727
1996 TUS MS        START  23  TASK      41  JOB      3 TI=727 LENGTH  RATE
                   PATH  60013        10       70001               8    60
1996 TUS M E       END    23  TASK      41  JOB      3 TI=727
1997 TUS    T  E   END        TASK      41  JOB      3 TI=727
1997 TUS    T X    EXECUTING  TASK      40  JOB      3 TI=726
1997 TUS MS        START  22  TASK      40  JOB      3 TI=726 LENGTH  RATE
                   PATH  70001        12       60015               2    60
1997 TUS M E       END    22  TASK      40  JOB      3 TI=726
1997 TUS MS        START  22  TASK      40  JOB      3 TI=726 LENGTH  RATE
                   PATH  70001        11       60014               2    60
1997 TUS M E       END    22  TASK      40  JOB      3 TI=726
1997 TUS MS        START  23  TASK      40  JOB      3 TI=726 LENGTH  RATE
                   PATH  60015        12       70001               8    60
1997 TUS M E       END    23  TASK      40  JOB      3 TI=726
1997 TUS MS        START  22  TASK      40  JOB      3 TI=726 LENGTH  RATE
                   PATH  70001        10       60013               2    60
1997 TUS M E       END    22  TASK      40  JOB      3 TI=726
1997 TUS MS        START  23  TASK      40  JOB      3 TI=726 LENGTH  RATE
                   PATH  60014        11       70001               8    60
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   1997 TUS M E       END    23  TASK      40  JOB      3 TI=726
   1997 TUS MS        START  23  TASK      40  JOB      3 TI=726 LENGTH  RATE
                      PATH  60013        10        70001                8    60
   1997 TUS M E       END    23  TASK      40  JOB      3 TI=726
   1998 TUS    T  E   END        TASK      40  JOB      3 TI=726
   1998 TUS    T X    EXECUTING  TASK      50  JOB      3 TI=731
   1998 TUS MS        START  53  TASK      50  JOB      3 TI=731 LENGTH  RATE
                      PATH  70001        13        60016               14    60
   1998 TUS M E       END    53  TASK      50  JOB      3 TI=731
   1998 TUS MS        START  53  TASK      50  JOB      3 TI=731 LENGTH  RATE
                      PATH  70001        12        60015               14    60
   1998 TUS M E       END    53  TASK      50  JOB      3 TI=731
   1998 TUS MS        START  53  TASK      50  JOB      3 TI=731 LENGTH  RATE
                      PATH  70001        11        60014               14    60
   1998 TUS M E       END    53  TASK      50  JOB      3 TI=731
   1998 TUS MS        START  53  TASK      50  JOB      3 TI=731 LENGTH  RATE
                      PATH  70001        10        60013               14    60
   1998 TUS M E       END    53  TASK      50  JOB      3 TI=731
   1999 TUS    T  E   END        TASK      50  JOB      3 TI=731
   1999 TUS    T X    EXECUTING  TASK     203  JOB      2 TI=720
   1999 TUS MS        START  44  TASK     203  JOB      2 TI=720 LENGTH  RATE
                      PATH  70001        22        60033                2    60
   1999 TUS M E       END    44  TASK     203  JOB      2 TI=720
   1999 TUS MS        START  44  TASK     203  JOB      2 TI=720 LENGTH  RATE
                      PATH  70001        22        60032                2    60
   1999 TUS M E       END    44  TASK     203  JOB      2 TI=720
   1999 TUS MS        START  45  TASK     203  JOB      2 TI=720 LENGTH  RATE
                      PATH  60033        22        70001               48    60
   1999 TUS M E       END    45  TASK     203  JOB      2 TI=720
   1999 TUS MS        START  44  TASK     203  JOB      2 TI=720 LENGTH  RATE
                      PATH  70001        22        60031                2    60
   1999 TUS M E       END    44  TASK     203  JOB      2 TI=720
   1999 TUS MS        START  45  TASK     203  JOB      2 TI=720 LENGTH  RATE
                      PATH  60032        22        70001               38    60
   1999 TUS M E       END    45  TASK     203  JOB      2 TI=720
   1999 TUS MS        START  44  TASK     203  JOB      2 TI=720 LENGTH  RATE
                      PATH  70001        22        60030                2    60
   1999 TUS M E       END    44  TASK     203  JOB      2 TI=720
   1999 TUS MS        START  45  TASK     203  JOB      2 TI=720 LENGTH  RATE
                      PATH  60031        22        70001               42    60
   1999 TUS M E       END    45  TASK     203  JOB      2 TI=720
   1999 TUS MS        START  45  TASK     203  JOB      2 TI=720 LENGTH  RATE
                      PATH  60030        22        70001               32    60
   1999 TUS M E       END    45  TASK     203  JOB      2 TI=720
** AT TIME  2000 , EVENT     1 IN MAJOR MODE  102 OCCURRED.
   2000 TUS    TG     GO FOR     TASK     175
**AT TIME   2000 TRANSITION TO MAJOR MODE  102 OCCURRED.
** AT TIME    2000 COUNTDOWN CLOCK IS AT -    0 SECONDS AND COUNTING.
   2000 TUS    T    I INTERRUPT  TASK     203  JOB      2 TI=720
   2000 TUS    TG     GO FOR     TASK     165
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2000 TUS     T     I INTERRUPT  TASK     175  JOB      4 TI=756
2000 TUS     TG     GO FOR      TASK     193
2000 TUS     T X    EXECUTING   TASK     165  JOB      2 TI=714
2000 TUS MS         START  46   TASK     165  JOB      2 TI=714 LENGTH  RATE
                    PATH  70001        13       60016                2    60
2000 TUS M E        END    46   TASK     165  JOB      2 TI=714
2000 TUS MS         START  46   TASK     165  JOB      2 TI=714 LENGTH  RATE
                    PATH  70001        12       60015                2    60
2000 TUS M E        END    46   TASK     165  JOB      2 TI=714
2000 TUS MS         START  47   TASK     165  JOB      2 TI=714 LENGTH  RATE
                    PATH  60016        13       70001                4    60
2000 TUS M E        END    47   TASK     165  JOB      2 TI=714
2000 TUS MS         START  46   TASK     165  JOB      2 TI=714 LENGTH  RATE
                    PATH  70001        11       60014                2    60
2000 TUS M E        END    46   TASK     165  JOB      2 TI=714
2000 TUS MS         START  47   TASK     165  JOB      2 TI=714 LENGTH  RATE
                    PATH  60015        12       70001                4    60
2000 TUS M E        END    47   TASK     165  JOB      2 TI=714
2000 TUS MS         START  46   TASK     165  JOB      2 TI=714 LENGTH  RATE
                    PATH  70001        10       60013                2    60
2000 TUS M E        END    46   TASK     165  JOB      2 TI=714
2000 TUS MS         START  47   TASK     165  JOB      2 TI=714 LENGTH  RATE
                    PATH  60014        11       70001                4    60
2000 TUS M E        END    47   TASK     165  JOB      2 TI=714
2000 TUS MS         START  47   TASK     165  JOB      2 TI=714 LENGTH  RATE
                    PATH  60013        10       70001                4    60
2000 TUS M E        END    47   TASK     165  JOB      2 TI=714
2000 TUS     TG     GO FOR      TASK       6
2000 TUS     TG     GO FOR      TASK     335
                    *** ABORTED ***
2000 TUS     T   W  MSG WAIT    TASK     165  JOB      2 TI=714
2000 TUS     T X    EXECUTING   TASK     175  JOB      4 TI=756
2000 TUS     T  E   END         TASK     203  JOB      2 TI=720
2001 TUS     T     I INTERRUPT  TASK     175  JOB      4 TI=756
2001 TUS     T X    EXECUTING   TASK     165  JOB      2 TI=714
2001 TUS MS         START  64   TASK     165  JOB      2 TI=714 LENGTH  RATE
                    PATH  70001        10       60013                4    60
2001 TUS M E        END    64   TASK     165  JOB      2 TI=714
2001 TUS MS         START  65   TASK     165  JOB      2 TI=714 LENGTH  RATE
                    PATH  70001        11       60014                4    60
2001 TUS M E        END    65   TASK     165  JOB      2 TI=714
2001 TUS MS         START  66   TASK     165  JOB      2 TI=714 LENGTH  RATE
                    PATH  70001        12       60015                4    60
2001 TUS M E        END    66   TASK     165  JOB      2 TI=714
2001 TUS     T  E   END         TASK     165  JOB      2 TI=714
2001 TUS     T  E   END         TASK     175  JOB      4 TI=756
2001 TUS     T X    EXECUTING   TASK     193  JOB      3 TI=745
2001 TUS MS         START  46   TASK     193  JOB      3 TI=745 LENGTH  RATE
                    PATH  70001        13       60016                2    60
2001 TUS M E        END    46   TASK     193  JOB      3 TI=745
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2001 TUS MS       START  46  TASK    193  JOB      3 TI=745 LENGTH  RATE
                  PATH  70001       12       60015              2    60
2001 TUS M E      END    46  TASK    193  JOB      3 TI=745
2001 TUS MS       START  47  TASK    193  JOB      3 TI=745 LENGTH  RATE
                  PATH  60016       13       70001             16    60
2001 TUS M E      END    47  TASK    193  JOB      3 TI=745
2001 TUS MS       START  46  TASK    193  JOB      3 TI=745 LENGTH  RATE
                  PATH  70001       11       60014              2    60
2001 TUS M E      END    46  TASK    193  JOB      3 TI=745
2001 TUS MS       START  47  TASK    193  JOB      3 TI=745 LENGTH  RATE
                  PATH  60015       12       70001             16    60
2001 TUS M E      END    47  TASK    193  JOB      3 TI=745
2001 TUS MS       START  46  TASK    193  JOB      3 TI=745 LENGTH  RATE
                  PATH  70001       10       60013              2    60
2001 TUS M E      END    46  TASK    193  JOB      3 TI=745
2001 TUS MS       START  47  TASK    193  JOB      3 TI=745 LENGTH  RATE
                  PATH  60014       11       70001             16    60
2001 TUS M E      END    47  TASK    193  JOB      3 TI=745
2001 TUS MS       START  47  TASK    193  JOB      3 TI=745 LENGTH  RATE
                  PATH  60013       10       70001             16    60
2001 TUS M E      END    47  TASK    193  JOB      3 TI=745
2002 TUS    T  E  END       TASK    193  JOB      3 TI=745
2002 TUS    T X   EXECUTING TASK     91  JOB      4 TI=747
2002 TUS MS       START   6  TASK     91  JOB      4 TI=747 LENGTH  RATE
                  PATH  70001       12       60011              2    60
2002 TUS M E      END     6  TASK     91  JOB      4 TI=747
2002 TUS MS       START  22  TASK     91  JOB      4 TI=747 LENGTH  RATE
                  PATH  70001       12       60015              2    60
2002 TUS M E      END    22  TASK     91  JOB      4 TI=747
2002 TUS MS       START  38  TASK     91  JOB      4 TI=747 LENGTH  RATE
                  PATH  70001       13       60012              2    60
2002 TUS M E      END    38  TASK     91  JOB      4 TI=747
2002 TUS MS       START  46  TASK     91  JOB      4 TI=747 LENGTH  RATE
                  PATH  70001       13       60016              2    60
2002 TUS M E      END    46  TASK     91  JOB      4 TI=747
2002 TUS MS       START   6  TASK     91  JOB      4 TI=747 LENGTH  RATE
                  PATH  70001       11       60010              2    60
2002 TUS M E      END     6  TASK     91  JOB      4 TI=747
2002 TUS MS       START   7  TASK     91  JOB      4 TI=747 LENGTH  RATE
                  PATH  60011       12       70001              2    60
2002 TUS M E      END     7  TASK     91  JOB      4 TI=747
2002 TUS MS       START  22  TASK     91  JOB      4 TI=747 LENGTH  RATE
                  PATH  70001       11       60014              2    60
2002 TUS M E      END    22  TASK     91  JOB      4 TI=747
2002 TUS MS       START  23  TASK     91  JOB      4 TI=747 LENGTH  RATE
                  PATH  60015       12       70001              2    60
2002 TUS M E      END    23  TASK     91  JOB      4 TI=747
2002 TUS MS       START  38  TASK     91  JOB      4 TI=747 LENGTH  RATE
                  PATH  70001       12       60011              2    60
2002 TUS M E      END    38  TASK     91  JOB      4 TI=747
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2002 TUS MS      START  39  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  60012      13       70001              20    60
2002 TUS M E     END    39  TASK     91  JOB      4 TI=747
2002 TUS MS      START  46  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  70001      12       60015               2    60
2002 TUS M E     END    46  TASK     91  JOB      4 TI=747
2002 TUS MS      START  47  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  60016      13       70001               4    60
2002 TUS M E     END    47  TASK     91  JOB      4 TI=747
2002 TUS MS      START   6  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  70001      10       60009               2    60
2002 TUS M E     END     6  TASK     91  JOB      4 TI=747
2002 TUS MS      START   7  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  60010      11       70001               2    60
2002 TUS M E     END     7  TASK     91  JOB      4 TI=747
2002 TUS MS      START  22  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  70001      10       60013               2    60
2002 TUS M E     END    22  TASK     91  JOB      4 TI=747
2002 TUS MS      START  23  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  60014      11       70001               2    60
2002 TUS M E     END    23  TASK     91  JOB      4 TI=747
2002 TUS MS      START  38  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  70001      11       60010               2    60
2002 TUS M E     END    38  TASK     91  JOB      4 TI=747
2002 TUS MS      START  39  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  60011      12       70001              32    60
2002 TUS M E     END    39  TASK     91  JOB      4 TI=747  ———
2002 TUS MS      START  46  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  70001      11       60014               2    60
2002 TUS M E     END    46  TASK     91  JOB      4 TI=747
2002 TUS MS      START  47  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  60015      12       70001               4    60
2002 TUS M E     END    47  TASK     91  JOB      4 TI=747
2002 TUS MS      START   7  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  60009      10       70001               2    60
2002 TUS M E     END     7  TASK     91  JOB      4 TI=747
2002 TUS MS      START  23  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  60013      10       70001               2    60
2002 TUS M E     END    23  TASK     91  JOB      4 TI=747
2002 TUS MS      START  38  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  70001      10       60009               2    60
2002 TUS M E     END    38  TASK     91  JOB      4 TI=747
2002 TUS MS      START  39  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  60010      11       70001              20    60
2002 TUS M E     END    39  TASK     91  JOB      4 TI=747
2002 TUS MS      START  46  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  70001      10       60013               2    60
2002 TUS M E     END    46  TASK     91  JOB      4 TI=747
2002 TUS MS      START  47  TASK     91  JOB      4 TI=747 LENGTH  RATE
                 PATH  60014      11       70001               4    60
```

```
2002 TUS M E      END    47  TASK     91  JOB      4 TI=747
2002 TUS MS       START  39  TASK     91  JOB      4 TI=747 LENGTH  RATE
                  PATH  60009      10       70001              32    60
2002 TUS M E      END    39  TASK     91  JOB      4 TI=747
2002 TUS MS       START  47  TASK     91  JOB      4 TI=747 LENGTH  RATE
                  PATH  60013      10       70001               4    60
2002 TUS M E      END    47  TASK     91  JOB      4 TI=747
2004 TUS    T  E  END        TASK     91  JOB      4 TI=747
2004 TUS    T X   EXECUTING  TASK     52  JOB      2 TI=712
2004 TUS    T   W MSG WAIT   TASK     52  JOB      2 TI=712
2004 TUS    T X   EXECUTING  TASK    120  JOB      3 TI=740
2004 TUS MS       START  22  TASK     52  JOB      2 TI=712 LENGTH  RATE
                  PATH  70001      12       60015               2    60
2004 TUS M E      END    22  TASK     52  JOB      2 TI=712
2004 TUS    T    I INTERRUPT  TASK    120  JOB      3 TI=740
2004 TUS    T X   EXECUTING  TASK     52  JOB      2 TI=712
2004 TUS    T   W MSG WAIT   TASK     52  JOB      2 TI=712
2004 TUS    T X   EXECUTING  TASK    120  JOB      3 TI=740
2004 TUS MS       START  22  TASK    120  JOB      3 TI=740 LENGTH  RATE
                  PATH  70001      12       60015               2    60
2004 TUS M E      END    22  TASK    120  JOB      3 TI=740
2004 TUS MS       START  46  TASK    120  JOB      3 TI=740 LENGTH  RATE
                  PATH  70001      13       60016               2    60
2004 TUS M E      END    46  TASK    120  JOB      3 TI=740
2004 TUS MS       START  23  TASK     52  JOB      2 TI=712 LENGTH  RATE
                  PATH  60015      12       70001               4    60
2004 TUS M E      END    23  TASK     52  JOB      2 TI=712
2004 TUS MS       START  22  TASK     52  JOB      2 TI=712 LENGTH  RATE
                  PATH  70001      11       60014               2    60
2004 TUS M E      END    22  TASK     52  JOB      2 TI=712
2004 TUS    T    I INTERRUPT  TASK    120  JOB      3 TI=740
2004 TUS    T X   EXECUTING  TASK     52  JOB      2 TI=712
2004 TUS    T   W MSG WAIT   TASK     52  JOB      2 TI=712
2004 TUS    T X   EXECUTING  TASK    120  JOB      3 TI=740
2004 TUS MS       START  22  TASK    120  JOB      3 TI=740 LENGTH  RATE
                  PATH  70001      11       60014               2    60
2004 TUS M E      END    22  TASK    120  JOB      3 TI=740
2004 TUS MS       START  23  TASK    120  JOB      3 TI=740 LENGTH  RATE
                  PATH  60015      12       70001               8    60
2004 TUS M E      END    23  TASK    120  JOB      3 TI=740
2004 TUS MS       START  46  TASK    120  JOB      3 TI=740 LENGTH  RATE
                  PATH  70001      12       60015               2    60
2004 TUS M E      END    46  TASK    120  JOB      3 TI=740
2004 TUS MS       START  47  TASK    120  JOB      3 TI=740 LENGTH  RATE
                  PATH  60016      13       70001               2    60
2004 TUS M E      END    47  TASK    120  JOB      3 TI=740
2004 TUS MS       START  23  TASK     52  JOB      2 TI=712 LENGTH  RATE
                  PATH  60014      11       70001               4    60
2004 TUS M E      END    23  TASK     52  JOB      2 TI=712
2004 TUS MS       START  22  TASK     52  JOB      2 TI=712 LENGTH  RATE
```

```
                    PATH  70001      10       60013                2    60
2004 TUS M E        END    22  TASK    52  JOB      2 TI=712
2004 TUS MS         START  22  TASK   120  JOB      3 TI=740 LENGTH  RATE
                    PATH  70001      10       60013                2    60
2004 TUS M E        END    22  TASK   120  JOB      3 TI=740
2004 TUS MS         START  23  TASK   120  JOB      3 TI=740 LENGTH  RATE
                    PATH  60014      11       70001                8    60
2004 TUS M E        END    23  TASK   120  JOB      3 TI=740
2004 TUS MS         START  46  TASK   120  JOB      3 TI=740 LENGTH  RATE
                    PATH  70001      11       60014                2    60
2004 TUS M E        END    46  TASK   120  JOB      3 TI=740
2004 TUS MS         START  47  TASK   120  JOB      3 TI=740 LENGTH  RATE
                    PATH  60015      12       70001                2    60
2004 TUS M E        END    47  TASK   120  JOB      3 TI=740
2004 TUS MS         START  23  TASK    52  JOB      2 TI=712 LENGTH  RATE
                    PATH  60013      10       70001                4    60
2004 TUS M E        END    23  TASK    52  JOB      2 TI=712
2004 TUS    T  E    END        TASK    52  JOB      2 TI=712
2004 TUS MS         START  23  TASK   120  JOB      3 TI=740 LENGTH  RATE
                    PATH  60013      10       70001                8    60
2004 TUS M E        END    23  TASK   120  JOB      3 TI=740
2004 TUS MS         START  46  TASK   120  JOB      3 TI=740 LENGTH  RATE
                    PATH  70001      10       60013                2    60
2004 TUS M E        END    46  TASK   120  JOB      3 TI=740
2004 TUS MS         START  47  TASK   120  JOB      3 TI=740 LENGTH  RATE
                    PATH  60014      11       70001                2    60
2004 TUS M E        END    47  TASK   120  JOB      3 TI=740
2004 TUS MS         START  47  TASK   120  JOB      3 TI=740 LENGTH  RATE
                    PATH  60013      10       70001                2    60
2004 TUS M E        END    47  TASK   120  JOB      3 TI=740
2005 TUS    T  E    END        TASK   120  JOB      3 TI=740
2005 TUS    T X     EXECUTING  TASK   119  JOB      3 TI=739
2005 TUS MS         START  46  TASK   119  JOB      3 TI=739 LENGTH  RATE
                    PATH  70001      13       60016                2    60
2005 TUS M E        END    46  TASK   119  JOB      3 TI=739
2005 TUS MS         START  46  TASK   119  JOB      3 TI=739 LENGTH  RATE
                    PATH  70001      12       60015                2    60
2005 TUS M E        END    46  TASK   119  JOB      3 TI=739
2005 TUS MS         START  47  TASK   119  JOB      3 TI=739 LENGTH  RATE
                    PATH  60016      13       70001                2    60
2005 TUS M E        END    47  TASK   119  JOB      3 TI=739
2005 TUS MS         START  46  TASK   119  JOB      3 TI=739 LENGTH  RATE
                    PATH  70001      11       60014                2    60
2005 TUS M E        END    46  TASK   119  JOB      3 TI=739
2005 TUS MS         START  47  TASK   119  JOB      3 TI=739 LENGTH  RATE
                    PATH  60015      12       70001                2    60
2005 TUS M E        END    47  TASK   119  JOB      3 TI=739
2005 TUS MS         START  46  TASK   119  JOB      3 TI=739 LENGTH  RATE
                    PATH  70001      10       60013                2    60
2005 TUS M E        END    46  TASK   119  JOB      3 TI=739
```

```
2005 TUS MS        START  47  TASK    119  JOB      3 TI=739 LENGTH  RATE
                   PATH  60014       11       70001               2    60
2005 TUS M E       END    47  TASK    119  JOB      3 TI=739
2005 TUS MS        START  47  TASK    119  JOB      3 TI=739 LENGTH  RATE
                   PATH  60013       10       70001               2    60
2005 TUS M E       END    47  TASK    119  JOB      3 TI=739
2006 TUS    T  E   END        TASK    119  JOB      3 TI=739
2006 TUS    T X    EXECUTING  TASK     42  JOB      3 TI=728
2006 TUS    T   W  MSG WAIT   TASK     42  JOB      3 TI=728
2006 TUS    T X    EXECUTING  TASK    114  JOB      4 TI=751
2006 TUS    T   W  MSG WAIT   TASK    114  JOB      4 TI=751
2006 TUS    T X    EXECUTING  TASK    333  JOB      5 TI=761
2006 TUS MS        START   6  TASK     42  JOB      3 TI=728 LENGTH  RATE
                   PATH  70001       12       60011               2    60
2006 TUS M E       END     6  TASK     42  JOB      3 TI=728
2006 TUS    T    I INTERRUPT TASK    333  JOB      5 TI=761
2006 TUS    T X    EXECUTING  TASK     42  JOB      3 TI=728
2006 TUS    T   W  MSG WAIT   TASK     42  JOB      3 TI=728
2006 TUS    T X    EXECUTING  TASK    333  JOB      5 TI=761
2006 TUS MS        START  24  TASK    114  JOB      4 TI=751 LENGTH  RATE
                   PATH  70001       13       60016               6    60
2006 TUS M E       END    24  TASK    114  JOB      4 TI=751
2006 TUS    T    I INTERRUPT TASK    333  JOB      5 TI=761
2006 TUS    T X    EXECUTING  TASK    114  JOB      4 TI=751
2006 TUS    T   W  MSG WAIT   TASK    114  JOB      4 TI=751
2006 TUS    T X    EXECUTING  TASK    333  JOB      5 TI=761
2006 TUS MS        START  26  TASK    114  JOB      4 TI=751 LENGTH  RATE
                   PATH  70001       11       60014               2    60
2006 TUS M E       END    26  TASK    114  JOB      4 TI=751
2006 TUS    T    I INTERRUPT TASK    333  JOB      5 TI=761
2006 TUS    T X    EXECUTING  TASK    114  JOB      4 TI=751
2006 TUS    T   W  MSG WAIT   TASK    114  JOB      4 TI=751
2006 TUS    T X    EXECUTING  TASK    333  JOB      5 TI=761
2006 TUS    T  E   END        TASK    333  JOB      5 TI=761
2006 TUS    T X    EXECUTING  TASK    180  JOB      2 TI=717
2006 TUS MS        START  64  TASK    114  JOB      4 TI=751 LENGTH  RATE
                   PATH  70001       10       60013               6    60
2006 TUS M E       END    64  TASK    114  JOB      4 TI=751
2006 TUS MS        START  65  TASK    114  JOB      4 TI=751 LENGTH  RATE
                   PATH  70001       11       60014               6    60
2006 TUS M E       END    65  TASK    114  JOB      4 TI=751
2006 TUS MS        START  66  TASK    114  JOB      4 TI=751 LENGTH  RATE
                   PATH  70001       12       60015               6    60
2006 TUS M E       END    66  TASK    114  JOB      4 TI=751
2006 TUS MS        START  67  TASK    114  JOB      4 TI=751 LENGTH  RATE
                   PATH  70001       13       60016               6    60
2006 TUS M E       END    67  TASK    114  JOB      4 TI=751
2006 TUS MS        START   7  TASK     42  JOB      3 TI=728 LENGTH  RATE
                   PATH  60011       12       70001               4    60
2006 TUS M E       END     7  TASK     42  JOB      3 TI=728
```

```
2006 TUS MS       START   6 TASK     42 JOB      3 TI=728 LENGTH  RATE
                  PATH  70001       11       60010              2    60
2006 TUS M E      END     6 TASK     42 JOB      3 TI=728
2006 TUS    T   I INTERRUPT TASK    180 JOB      2 TI=717
2006 TUS    T X   EXECUTING TASK     42 JOB      3 TI=728
2006 TUS    T   W MSG WAIT  TASK     42 JOB      3 TI=728
2006 TUS    T X   EXECUTING TASK    180 JOB      2 TI=717
2006 TUS MS       START  25 TASK    114 JOB      4 TI=751 LENGTH  RATE
                  PATH  60016       13       70001              2    60
2006 TUS M E      END    25 TASK    114 JOB      4 TI=751
2006 TUS MS       START  24 TASK    114 JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       12       60015              6    60
2006 TUS M E      END    24 TASK    114 JOB      4 TI=751
2006 TUS MS       START  27 TASK    114 JOB      4 TI=751 LENGTH  RATE
                  PATH  60014       11       70001              2    60
2006 TUS M E      END    27 TASK    114 JOB      4 TI=751
2006 TUS MS       START  26 TASK    114 JOB      4 TI=751 LENGTH  RATE
                  PATH  70001       10       60013              2    60
2006 TUS M E      END    26 TASK    114 JOB      4 TI=751
2006 TUS MS       START   6 TASK    180 JOB      2 TI=717 LENGTH  RATE
                  PATH  70001       12       60011              2    60
2006 TUS M E      END     6 TASK    180 JOB      2 TI=717
2006 TUS MS       START  38 TASK    180 JOB      2 TI=717 LENGTH  RATE
                  PATH  70001       13       60012              2    60
2006 TUS M E      END    38 TASK    180 JOB      2 TI=717
2006 TUS MS       START   7 TASK     42 JOB      3 TI=728 LENGTH  RATE
                  PATH  60010       11       70001              4    60
2006 TUS M E      END     7 TASK     42 JOB      3 TI=728
2006 TUS MS       START   6 TASK     42 JOB      3 TI=728 LENGTH  RATE
                  PATH  70001       10       60009              2    60
2006 TUS M E      END     6 TASK     42 JOB      3 TI=728
2006 TUS MS       START  25 TASK    114 JOB      4 TI=751 LENGTH  RATE
                  PATH  60015       12       70001              2    60
2006 TUS M E      END    25 TASK    114 JOB      4 TI=751
2006 TUS MS       START  27 TASK    114 JOB      4 TI=751 LENGTH  RATE
                  PATH  60013       10       70001              2    60
2006 TUS M E      END    27 TASK    114 JOB      4 TI=751
2006 TUS    T  E  END       TASK    114 JOB      4 TI=751
2006 TUS MS       START   6 TASK    180 JOB      2 TI=717 LENGTH  RATE
                  PATH  70001       11       60010              2    60
2006 TUS M E      END     6 TASK    180 JOB      2 TI=717
2006 TUS MS       START   7 TASK    180 JOB      2 TI=717 LENGTH  RATE
                  PATH  60011       12       70001              2    60
2006 TUS M E      END     7 TASK    180 JOB      2 TI=717
2006 TUS MS       START  38 TASK    180 JOB      2 TI=717 LENGTH  RATE
                  PATH  70001       12       60011              2    60
2006 TUS M E      END    38 TASK    180 JOB      2 TI=717
2006 TUS MS       START  39 TASK    180 JOB      2 TI=717 LENGTH  RATE
                  PATH  60012       13       70001              8    60
2006 TUS M E      END    39 TASK    180 JOB      2 TI=717
```

```
2006 TUS MS        START   7  TASK     42  JOB      3 TI=728 LENGTH  RATE
                   PATH  60009       10       70001              4    60
2006 TUS M E       END     7  TASK     42  JOB      3 TI=728
2006 TUS    T  E   END        TASK     42  JOB      3 TI=728
2006 TUS MS        START   6  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  70001       10       60009              2    60
2006 TUS M E       END     6  TASK    180  JOB      2 TI=717
2006 TUS MS        START   7  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  60010       11       70001              2    60
2006 TUS M E       END     7  TASK    180  JOB      2 TI=717
2006 TUS MS        START  38  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  70001       11       60010              2    60
2006 TUS M E       END    38  TASK    180  JOB      2 TI=717
2006 TUS MS        START  39  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  60011       12       70001             14    60
2006 TUS M E       END    39  TASK    180  JOB      2 TI=717
2006 TUS MS        START   7  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  60009       10       70001              2    60
2006 TUS M E       END     7  TASK    180  JOB      2 TI=717
2006 TUS MS        START  38  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  70001       10       60009              2    60
2006 TUS M E       END    38  TASK    180  JOB      2 TI=717
2006 TUS MS        START  39  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  60010       11       70001             14    60
2006 TUS M E       END    39  TASK    180  JOB      2 TI=717
2006 TUS MS        START  39  TASK    180  JOB      2 TI=717 LENGTH  RATE
                   PATH  60009       10       70001             14    60
2006 TUS M E       END    39  TASK    180  JOB      2 TI=717
2007 TUS    T  E   END        TASK    180  JOB      2 TI=717
2007 TUS    T X    EXECUTING  TASK     15  JOB      2 TI=709
2020 TUS    TG     GO FOR     TASK    307
2020 TUS    T    I INTERRUPT  TASK     15  JOB      2 TI=709
2020 TUS    TG     GO FOR     TASK    181
2020 TUS    T X    EXECUTING  TASK    307  JOB      5 TI=759
2020 TUS    TG     GO FOR     TASK    306
2020 TUS MS        START  29  TASK    307  JOB      5 TI=759 LENGTH  RATE
                   PATH  70001        1       70004            256    60
2020 TUS    TG     GO FOR     TASK    176
2020 TUS MS        START  29  TASK    307  JOB      5 TI=759 LENGTH  RATE
                   PATH  70001        3       70003            256    60
2020 TUS    TG     GO FOR     TASK    309
2020 TUS MS        START  29  TASK    307  JOB      5 TI=759 LENGTH  RATE
                   PATH  70001        2       70002            256    60
2020 TUS    TG     GO FOR     TASK     62
2020 TUS MS        START  28  TASK    307  JOB      5 TI=759 LENGTH  RATE
                   PATH  70004        4       70001            256    60
2020 TUS    TG     GO FOR     TASK     40
2020 TUS MS        START  58  TASK    307  JOB      5 TI=759 LENGTH  RATE
                   PATH  70001       24       60095            512    60
2020 TUS    TG     GO FOR     TASK     60
```

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2020 TUS    TG    GO FOR    TASK    91
2020 TUS    TG    GO FOR    TASK    41
2020 TUS    TG    GO FOR    TASK    50
2020 TUS    TG    GO FOR    TASK   203
2020 TUS    TG    GO FOR    TASK    52
2020 TUS    TG    GO FOR    TASK   120
2020 TUS    TG    GO FOR    TASK   119
2020 TUS    TG    GO FOR    TASK    42
```

APPENDIX D

SUMMARY OUTPUT REPORTS

This appendix provides some of the statistical and control reports as specified in sections 5 2.5 1 and 5 2 5.2.

Statistical summaries for three different runs are given, viz ,

1. For a 100 ms simulation run starting at countdown To - 20 seconds and running through countdown To - 19 seconds

2 For a 120 ms simulation run starting at To - 1 and continuing through liftoff to event 19 in Major Mode 102

3 For a 550 ms simulation run starting at event 36 in Major Mode 103 and continuing through the transition to Major Mode 104 and OMS Ignition

Statistical and Control Reports for other runs are available for inspection at SDC in Santa Monica, California.

```
DURING    0.10 SECONDS OF SIMULATED SHUTTLE OPERATIONS
A TOTAL OF     59 DIFFERENT FUNCTIONS WERE INTRODUCED.
THESE FUNCTIONS WERE ACTIVATED     65 TIMES, STATUS IS.
          56 WERE COMPLETED
          50 ARE WAITING FOR NEXT ACTIVATION
           8 ARE IN READY STATE, I.E. WAITING FOR CPU
           0 ARE WAITING FOR MESSAGES TO COMPLETE
           1 PRESENTLY EXECUTING, I.E. IN ACTIVE STATE
FUNCTIONS WERE INTERRUPTED     36 TIMES.
    0 FUNCTION ACTIVATIONS WERE ABORTED AS FUNCTION STILL ACTIVE.


A TOTAL OF    404 MESSAGES WERE SUCCESSFULLY TRANSMITTED.
        0 WERE IN BURST MODE OVER MULTIPLEXED DATA LINKS
        0 TRANSMISSIONS WERE FOR LOADING OF MEMORIES
        0 TRANSMISSIONS WERE INTERRUPTED BECAUSE OF BURST MODE
          OPERATIONS OR KILLING OF TASKS
        0 SOURCE-DRIVEN MESSAGES WERE LOST DUE TO BACKLOGGING.


DEVICE    1, CLASS       1, WAS INVOLVED IN      1 TRANSMISSIONS,
     AVERAGING      17   MS.  UTILIZATION WAS  16   PERCENT.
DEVICE    2, CLASS       1, WAS INVOLVED IN      1 TRANSMISSIONS,
     AVERAGING      17   MS   UTILIZATION WAS  16   PERCENT.
DEVICE    3, CLASS       1, WAS INVOLVED IN      1 TRANSMISSIONS,
     AVERAGING      17   MS.  UTILIZATION WAS  16   PERCENT.
DEVICE    9, CLASS       1, WAS INVOLVED IN     39 TRANSMISSIONS,
     AVERAGING       0   MS   UTILIZATION WAS   0   PERCENT
DEVICE   10, CLASS       1, WAS INVOLVED IN     31 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   11, CLASS       1, WAS INVOLVED IN     39 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   12, CLASS       1, WAS INVOLVED IN      6 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   13, CLASS       1, WAS INVOLVED IN     62 TRANSMISSIONS,
     AVERAGING    0.03MS   UTILIZATION WAS   1   PERCENT
DEVICE   14, CLASS       1, WAS INVOLVED IN     63 TRANSMISSIONS,
     AVERAGING    0.03MS   UTILIZATION WAS   1   PERCENT.
DEVICE   15, CLASS       1, WAS INVOLVED IN     60 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   16, CLASS       1, WAS INVOLVED IN     37 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   30, CLASS       1, WAS INVOLVED IN      4 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   31, CLASS       1, WAS INVOLVED IN      4 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   32, CLASS       1, WAS INVOLVED IN      4 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
```

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DEVICE   33, CLASS       1, WAS INVOLVED IN       4 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   95, CLASS       1, WAS INVOLVED IN       3 TRANSMISSIONS,
     AVERAGING       8   MS.  UTILIZATION WAS  23   PERCENT.

MEMORY    1, SIZE     125 PAGES, HELD AN AVERAGE OF       2.97PAGES,
     WITH A MAXIMUM OF       3 PAGES   THE POTENTIAL TRANSMISSION RATE
     IS       1400   CH/MS.  THE MAXIMUM ACHIEVED RATE WAS      540
     CH/MS, AND THE AVERAGE RATE WAS       48   CH/MS.
MEMORY    2, SIZE     125 PAGES, HELD AN AVERAGE OF       0   PAGES,
     WITH A MAXIMUM OF       0 PAGES   THE POTENTIAL TRANSMISSION RATE
     IS       1400   CH/MS.  THE MAXIMUM ACHIEVED RATE WAS       60
     CH/MS, AND THE AVERAGE RATE WAS        7.20CH/MS.
MEMORY    3, SIZE     125 PAGES, HELD AN AVERAGE OF       0   PAGES,
     WITH A MAXIMUM OF       0 PAGES.  THE POTENTIAL TRANSMISSION RATE
     IS       1400   CH/MS.  THE MAXIMUM ACHIEVED RATE WAS       60
     CH/MS, AND THE AVERAGE RATE WAS        7.20CH/MS.
MEMORY    4, SIZE     125 PAGES, HELD AN AVERAGE OF       0   PAGES,
     WITH A MAXIMUM OF       0 PAGES.  THE POTENTIAL TRANSMISSION RATE
     IS       1400   CH/MS.  THE MAXIMUM ACHIEVED RATE WAS      120
     CH/MS, AND THE AVERAGE RATE WAS        7.20CH/MS.
MEMORY   11, SIZE       1 PAGES, HELD AN AVERAGE OF       0   PAGES,
     WITH A MAXIMUM OF       0 PAGES.  THE POTENTIAL TRANSMISSION RATE
     IS         60   CH/MS.  THE MAXIMUM ACHIEVED RATE WAS       60
     CH/MS, AND THE AVERAGE RATE WAS        0.90CH/MS.
MEMORY   12, SIZE       1 PAGES, HELD AN AVERAGE OF       0   PAGES,
     WITH A MAXIMUM OF       0 PAGES   THE POTENTIAL TRANSMISSION RATE
     IS         60   ZH/MS   THE MAXIMUM ACHIEVED RATE WAS       60
     CH/MS, AND THE AVERAGE RATE WAS        0.90CH/MS.
MEMORY   13, SIZE       1 PAGES, HELD AN AVERAGE OF       0   PAGES,
     WITH A MAXIMUM OF       0 PAGES.  THE POTENTIAL TRANSMISSION RATE
     IS         60   CH/MS.  THE MAXIMUM ACHIEVED RATE WAS       60
     CH/MS, AND THE AVERAGE RATE WAS        0 90CH/MS.

PROCESSOR   1, V M.    1, WAS USED     126 TIMES FOR
     A TOTAL OF     97   MS   UTILIZATION WAS  96 PERCENT.

DATA LINK     1 WAS INVOLVED IN       7 TRANSMISSIONS, AVERAGING
          4   MS.  UTILIZATION WAS  27 PERCENT.
     POTENTIAL TRANSMISSION RATE IS      60   CH/MS
DATA LINK     2 WAS INVOLVED IN       5 TRANSMISSIONS, AVERAGING
          4   MS.  UTILIZATION WAS  19 PERCENT
     POTENTIAL TRANSMISSION RATE IS      60   CH/MS
DATA LINK     3 WAS INVOLVED IN       3 TRANSMISSIONS, AVERAGING
          4   MS.  UTILIZATION WAS  11 PERCENT.
     POTENTIAL TRANSMISSION RATE IS      60   CH/MS
DATA LINK     4 WAS INVOLVED IN       3 TRANSMISSIONS, AVERAGING
          4   MS.  UTILIZATION WAS  11 PERCENT
     POTENTIAL TRANSMISSION RATE IS      60   CH/MS.
DATA LINK     6 WAS INVOLVED IN       1 TRANSMISSIONS, AVERAGING
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        17   MS.  UTILIZATION WAS  16 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK     7 WAS INVOLVED IN       1 TRANSMISSIONS, AVERAGING
        17   MS.  UTILIZATION WAS  16 PERCENT
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK     8 WAS INVOLVED IN       1 TRANSMISSIONS, AVERAGING
        17   MS.  UTILIZATION WAS  16 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    10 WAS INVOLVED IN      95 TRANSMISSIONS, AVERAGING
         0.02MS.  UTILIZATION WAS   1 PERCENT
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    11 WAS INVOLVED IN      91 TRANSMISSIONS, AVERAGING
         0.02MS.  UTILIZATION WAS   1 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    12 WAS INVOLVED IN      99 TRANSMISSIONS, AVERAGING
         0   MS.  UTILIZATION WAS   0 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    13 WAS INVOLVED IN      43 TRANSMISSIONS, AVERAGING
         0   MS.  UTILIZATION WAS   0 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    14 WAS INVOLVED IN      23 TRANSMISSIONS, AVERAGING
         0.13MS.  UTILIZATION WAS   2 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    15 WAS INVOLVED IN       9 TRANSMISSIONS, AVERAGING
         0.33MS.  UTILIZATION WAS   2 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    16 WAS INVOLVED IN       3 TRANSMISSIONS, AVERAGING
         1   MS.  UTILIZATION WAS   2 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    17 WAS INVOLVED IN       1 TRANSMISSIONS, AVERAGING
         1   MS   UTILIZATION WAS   0 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    22 WAS INVOLVED IN      13 TRANSMISSIONS, AVERAGING
         0   MS.  UTILIZATION WAS   0 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    23 WAS INVOLVED IN       3 TRANSMISSIONS, AVERAGING
         0   MS.  UTILIZATION WAS   0 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    24 WAS INVOLVED IN       3 TRANSMISSIONS, AVERAGING
         8   MS.  UTILIZATION WAS  23 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.

DATA SET   1, ON STORAGE UNIT    1, AVERAGED     9950   CH, AND REACHED
     A MAXIMUM OF   10000 CH.
DATA SET   2, ON STORAGE UNIT    1, AVERAGED    10188.80CH, AND REACHED
     A MAXIMUM OF   10240 CH.
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KEY BLOCKS -

BLOCK	BACKLOG MAXIMUM	BACKLOG AVERAGE	BACKLOG CURRENT	AVERAGE DELAY (MS) ALL	AVERAGE DELAY (MS) DELAYED	TIME 0.20SEC.
1138	0	0	0	0	0	
1151	20	1.28	0	4	4	
1182	1	0	0	0	0	
1184	1	0.48	1	0.78	0	
1185	1	0	0	0	0	
1192	1	0	0	0	0	
1201	59	49.90	59	0	0	
1204	0	0	0	0	0	
1488	0	0	0	0	0	
1495	0	0	0	0	0	
1601	1	0	0	0	0	
1605	35	0.43	0	0.39	0	
1608	1	0	0	0	0	
1675	1	0	0	0	0	
1682	1	0	0	0	0	
1686	1	0	0	0	0	
1693	0	0	0	0	0	
1706	0	0	0	0	0	
1707	0	0	0	0	0	
1708	5	0.04	0	0.05	0	
1712	2	0.02	0	0.02	2	
1734	0	0	0	0	0	
1738	3	0.06	0	0.03	0	
1748	1	0	0	0	0	
1751	1	0	0	0.01	0	
1753	1	0	0	0	0	
1754	9	0.80	0	0.40	0	
1808	0	0	0	0	0	
1846	1	0	0	0	0	
1847	1	0	0	0	0	
1851	1	0	0	0	0	
1935	0	0	0	0	0	
1936	0	0	0	0	0	
3004	0	0	0	0	0	
3005	0	0	0	0	0	
3032	28	6 72	8	22.24	22.24	
3089	1	0	0	0	0	
6002	0	0	0	0	0	
8005	2	0.09	0	0.24	1.80	
9052	1	0	0	0	0	
11052	0	0	0	0	0	

SUMMARY FOR TIME 200 , RELATIVE TIME 200
TALLY SUMMARIES
TABLE 1 --
AVERAGE = 734.75 STANDARD DEVIATION = 14.40

P (5)	SCORE	DELTA	CUM,SCORE	PERCENT	CUM,PERCENT
706 - 706	0	0	0	0.00	0.00

707 -	707	0	0	0	0.00	0.00
708 -	708	0	0	0	0.00	0.00
709 -	709	0	0	0	0.00	0.00
710 -	710	0	0	0	0.00	0.00
711 -	711	0	0	0	0.00	0.00
712 -	712	3	3	3	4.62	4.62
713 -	713	0	-3	3	0.00	4.62
714 -	714	0	0	3	0.00	4.62
715 -	715	0	0	3	0.00	4.62
716 -	716	3	3	6	4 62	9.23
717 -	717	2	-1	8	3.08	12.31
718 -	718	0	-2	8	0.00	12.31
719 -	719	0	0	8	0.00	12.31
720 -	720	3	3	11	4.62	16.92
721 -	721	1	-2	12	1.54	18.46
722 -	722	0	-1	12	0.00	18.46
723 -	723	3	3	15	4.62	23.08
724 -	724	3	0	18	4 62	27.69
725 -	725	1	-2	19	1 54	29.23
726 -	726	3	2	22	4.62	33.85
727 -	727	3	0	25	4.62	38 46
728 -	728	3	0	28	4.62	43.08
729 -	729	0	-3	28	0.00	43.08
730 -	730	1	1	29	1 54	44.62
731 -	731	3	2	32	4.62	49.23
732 -	732	0	-3	32	0.00	49.23
733 -	733	3	3	35	4.62	53.85
734 -	734	3	0	38	4.62	58.46
735 -	735	0	-3	38	0.00	58.46
736 -	736	0	0	38	0.00	58.46
737 -	737	1	1	39	1.54	60.00
738 -	738	1	0	40	1.54	61 54
739 -	739	3	2	43	4.62	66.15
740 -	740	3	0	46	4 62	70.77
741 -	741	0	-3	46	0.00	70.77
742 -	742	3	3	49	4.62	75.38
743 -	743	0	-3	49	0 00	75.38
744 -	744	0	0	49	0 00	75.38
745 -	745	0	0	49	0 00	75.38
746 -	746	0	0	49	0.00	75.38
747 -	747	3	3	52	4.62	80.00
748 -	748	0	-3	52	0.00	80.00
749 -	749	1	1	53	1.54	81.54
750 -	750	1	0	54	1.54	83.08
751 -	751	2	1	56	3.08	86.15
752 -	752	0	-2	56	0.00	86.15
753 -	753	0	0	56	0.00	86.15
754 -	754	0	0	56	0.00	86.15
755 -	755	0	0	56	0.00	86.15
756 -	756	0	0	56	0.00	86.15

757 -	757	0	0	56	0 00	86.15
758 -	758	0	0	56	0.00	86.15
759 -	759	3	3	59	4.62	90.77
760 -	760	1	-2	60	1.54	92.31
761 -	761	3	2	63	4 62	96.92
762 -	762	0	-3	63	0.00	96.92
763 -	763	1	1	64	1.54	98.46
764 -	764	1	0	65	1.54	100.00

SUMMARY FOR TIME 200 , RELATIVE TIME 200

FACILITY	PERCENTAGE UTILIZATION	NUMBER OF TIMES USED	AVERAGE PERIOD PER USE	CURRENT PRIORITY	CURRENT RECOURSE	NUMBER SHELVED
1I	48.50	126	0.77	36	2000	
81U	8.50	2	8.50			
82U	8.50	2	8.50			
83U	8 50	2	8.50			
89U	0.00	78	0.00			
90U	0 00	62	0.00			
91U	0.00	78	0 00			
92U	0.00	12	0.00			
93U	1.00	124	0.02			
94U	1 00	126	0.02			
95U	0 00	120	0 00			
96U	0 00	74	0 00			
110U	0.00	8	0.00			
111U	0.00	8	0.00			
112U	0.00	8	0 00			
113U	0.00	8	0.00			
175U	12.00	6	4.00			
181U	14.00	7	4.00			
182U	10.00	5	4.00			
183U	6.00	3	4.00			
184U	6.00	3	4 00			
186U	8.50	1	17.00			
187U	8 50	1	17.00			
188U	8.50	1	17 00			
189U	1 00	95	0 02			
190U	1.00	91	0.02			
191U	0 00	99	0.00			
192U	0 00	43	0 00			
193U	1.50	23	0.13			
194U	1.50	9	0.33			
195U	1.50	3	1.00			
196U	0.50	1	1.00			
201U	0.00	13	0.00			
202U	0.00	3	0.00			
203U	12.00	3	8.00			

SUMMARY FOR TIME 200 , RELATIVE TIME 200

		CONTENTS			NUMBER	AVERAGE PERI(
STORAGE	CAPACITY	CURRENT	MAXIMUM	AVERAGE	WITHDRAWN	ALL UNITS
1	10000	10000	10000	9950.00	0	99.50
2	10240	10240	10240	10188.80	0	99.50
111	125	3	3	2.97	0	99 00
112	125	0	0	0.00	0	0.00
113	125	0	0	0.00	0	0.00
114	125	0	0	0.00	0	0.00
121	1	0	0	0.00	0	0.00
122	1	0	0	0.00	0	0.00
123	1	0	0	0.00	0	0.00
124	1	0	0	0 00	0	0.00
125	1	0	0	0.00	0	0 00
131	1400	0	540	48.00	24240	0.40
132	1400	0	60	7.20	360	4.00
133	1400	0	60	7.20	360	4 00
134	1400	0	120	7.20	360	4.00
141	60	0	60	0.90	540	0.33
142	60	0	60	0.90	540	0.33
143	60	0	60	0.90	540	0.33
144	60	0	0	0.00	0	0.00
145	60	0	0	0 00	0	0.00
151	17000000	20240	20240	20138 80	0	99.50
152	17000000	0	0	0.00	0	0.00

CURRENT TRANSACTION COUNT	480
MAXIMUM NUMBER OF TRANSACTIONS	491
NUMBER OF TRY OPERATIONS	99445
NUMBER OF TRANSACTION MOVES	308175
NUMBER OF VARIABLE EVALUATIONS	1069612
MAXIMUM VARIABLE RECURSION	5
NUMBER OF ADMIT ATTEMPTS	1119147
NUMBER OF FUNCTION POINTS	1579
NUMBER OF BLOCK SPACES USED	1830
NUMBER OF REPORT LINES	97
NUMBER OF VARIABLE ELEMENTS	1314
CURRENT UTILIZATION OF STACKS	2484

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DURING    0.12 SECONDS OF SIMULATED SHUTTLE OPERATIONS
A TOTAL OF     59 DIFFERENT FUNCTIONS WERE INTRODUCED.
THESE FUNCTIONS WERE ACTIVATED     90 TIMES, STATUS IS:
          61 WERE COMPLETED
          30 ARE WAITING FOR NEXT ACTIVATION
          28 ARE IN READY STATE, I.E. WAITING FOR CPU
           0 ARE WAITING FOR MESSAGES TO COMPLETE
           1 PRESENTLY EXECUTING, I.E. IN ACTIVE STATE
FUNCTIONS WERE INTERRUPTED     29 TIMES.
    1 FUNCTION ACTIVATIONS WERE ABORTED AS FUNCTION STILL ACTIVE.


A TOTAL OF    468 MESSAGES WERE SUCCESSFULLY TRANSMITTED.
        0 WERE IN BURST MODE OVER MULTIPLEXED DATA LINKS
        0 TRANSMISSIONS WERE FOR LOADING OF MEMORIES
        0 TRANSMISSIONS WERE INTERRUPTED BECAUSE OF BURST MODE
          OPERATIONS OR KILLING OF TASKS
        0 SOURCE-DRIVEN MESSAGES WERE LOST DUE TO BACKLOGGING.


DEVICE    9, CLASS       1, WAS INVOLVED IN      44 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   10, CLASS       1, WAS INVOLVED IN      41 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   11, CLASS       1, WAS INVOLVED IN      44 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   12, CLASS       1, WAS INVOLVED IN      10 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   13, CLASS       1, WAS INVOLVED IN      70 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   14, CLASS       1, WAS INVOLVED IN      70 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   15, CLASS       1, WAS INVOLVED IN      70 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   16, CLASS       1, WAS INVOLVED IN      39 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   30, CLASS       1, WAS INVOLVED IN       6 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   31, CLASS       1, WAS INVOLVED IN       6 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   32, CLASS       1, WAS INVOLVED IN       6 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   33, CLASS       1, WAS INVOLVED IN       6 TRANSMISSIONS,
     AVERAGING       0   MS.  UTILIZATION WAS   0   PERCENT.
DEVICE   95, CLASS       1, WAS INVOLVED IN       4 TRANSMISSIONS,
     AVERAGING    6.86MS.  UTILIZATION WAS  19   PERCENT.
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MEMORY    1, SIZE     125 PAGES, HELD AN AVERAGE OF       3   PAGES,
     WITH A MAXIMUM OF       3 PAGES.  THE POTENTIAL TRANSMISSION RATE
     IS       1400   CH/MS.  THE MAXIMUM ACHIEVED RATE WAS      360
     CH/MS, AND THE AVERAGE RATE WAS        3.12CH/MS.
MEMORY    2, SIZE     125 PAGES, HELD AN AVERAGE OF       0   PAGES,
     WITH A MAXIMUM OF       0 PAGES.  THE POTENTIAL TRANSMISSION RATE
     IS       1400   CH/MS.  THE MAXIMUM ACHIEVED RATE WAS       60
     CH/MS, AND THE AVERAGE RATE WAS        0.71CH/MS.
MEMORY    3, SIZE     125 PAGES, HELD AN AVERAGE OF       0   PAGES,
     WITH A MAXIMUM OF       0 PAGES.  THE POTENTIAL TRANSMISSION RATE
     IS       1400   CH/MS.  THE MAXIMUM ACHIEVED RATE WAS       60
     CH/MS, AND THE AVERAGE RATE WAS        0.71CH/MS.
MEMORY    4, SIZE     125 PAGES, HELD AN AVERAGE OF       0   PAGES,
     WITH A MAXIMUM OF       0 PAGES.  THE POTENTIAL TRANSMISSION RATE
     IS       1400   CH/MS.  THE MAXIMUM ACHIEVED RATE WAS      120
     CH/MS, AND THE AVERAGE RATE WAS        0.71CH/MS.
MEMORY   11, SIZE       1 PAGES, HELD AN AVERAGE OF       0   PAGES,
     WITH A MAXIMUM OF       0 PAGES.  THE POTENTIAL TRANSMISSION RATE
     IS         60   CH/MS   THE MAXIMUM ACHIEVED RATE WAS       60
     CH/MS, AND THE AVERAGE RATE WAS        0 09CH/MS.
MEMORY   12, SIZE       1 PAGES, HELD AN AVERAGE OF       0   PAGES,
     WITH A MAXIMUM OF       0 PAGES.  THE POTENTIAL TRANSMISSION RATE
     IS         60   CH/MS   THE MAXIMUM ACHIEVED RATE WAS       60
     CH/MS, AND THE AVERAGE RATE WAS        0.09CH/MS.
MEMORY   13, SIZE       1 PAGES, HELD AN AVERAGE OF       0   PAGES,
     WITH A MAXIMUM OF       0 PAGES.  THE POTENTIAL TRANSMISSION RATE
     IS         60   CH/MS   THE MAXIMUM ACHIEVED RATE WAS       60
     CH/MS, AND THE AVERAGE RATE WAS        0 09CH/MS
MEMORY   14, SIZE       1 PAGES, HELD AN AVERAGE OF       0   PAGES,
     WITH A MAXIMUM OF       0 PAGES.  THE POTENTIAL TRANSMISSION RATE
     IS         60   CH/MS.  THE MAXIMUM ACHIEVED RATE WAS       60
     CH/MS, AND THE AVERAGE RATE WAS        0   CH/MS
MEMORY   15, SIZE       1 PAGES, HELD AN AVERAGE OF       0   PAGES,
     WITH A MAXIMUM OF       0 PAGES.  THE POTENTIAL TRANSMISSION RATE
     IS         60   CH/MS.  THE MAXIMUM ACHIEVED RATE WAS       60
     CH/MS, AND THE AVERAGE RATE WAS        0   CH/MS.

PROCESSOR   1, V.M.    1, WAS USED     110 TIMES FOR
     A TOTAL OF    120   MS.  UTILIZATION WAS 100 PERCENT.

DATA LINK     1 WAS INVOLVED IN       8 TRANSMISSIONS, AVERAGING
          3.50MS.  UTILIZATION WAS  23 PERCENT
     POTENTIAL TRANSMISSION RATE IS      60   CH/MS.
DATA LINK     2 WAS INVOLVED IN       6 TRANSMISSIONS, AVERAGING
          3.33MS.  UTILIZATION WAS  16 PERCENT.
     POTENTIAL TRANSMISSION RATE IS      60   CH/MS.
DATA LINK     3 WAS INVOLVED IN       4 TRANSMISSIONS, AVERAGING
          3   MS.  UTILIZATION WAS   9 PERCENT.
     POTENTIAL TRANSMISSION RATE IS      60   CH/MS.
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DATA LINK     4 WAS INVOLVED IN      4 TRANSMISSIONS, AVERAGING
          3   MS.  UTILIZATION WAS   9 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    10 WAS INVOLVED IN     114 TRANSMISSIONS, AVERAGING
          0   MS.  UTILIZATION WAS   0 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    11 WAS INVOLVED IN     111 TRANSMISSIONS, AVERAGING
          0   MS.  UTILIZATION WAS   0 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    12 WAS INVOLVED IN     114 TRANSMISSIONS, AVERAGING
          0   MS.  UTILIZATION WAS   0 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    13 WAS INVOLVED IN      49 TRANSMISSIONS, AVERAGING
          0   MS.  UTILIZATION WAS   0 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    14 WAS INVOLVED IN      25 TRANSMISSIONS, AVERAGING
          0.12MS   UTILIZATION WAS   2 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    15 WAS INVOLVED IN       6 TRANSMISSIONS, AVERAGING
          0.50MS   UTILIZATION WAS   2 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS
DATA LINK    16 WAS INVOLVED IN       3 TRANSMISSIONS, AVERAGING
          1   MS   UTILIZATION WAS   2 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    17 WAS INVOLVED IN       1 TRANSMISSIONS, AVERAGING
          1   MS.  UTILIZATION WAS   0 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    22 WAS INVOLVED IN      21 TRANSMISSIONS, AVERAGING
          0   MS.  UTILIZATION WAS   0 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS.
DATA LINK    23 WAS INVOLVED IN       3 TRANSMISSIONS, AVERAGING
          0   MS.  UTILIZATION WAS   0 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS
DATA LINK    24 WAS INVOLVED IN       4 TRANSMISSIONS, AVERAGING
          6   MS.  UTILIZATION WAS  19 PERCENT.
     POTENTIAL TRANSMISSION RATE IS     60   CH/MS

DATA SET   1, ON STORAGE UNIT    1, AVERAGED     9995.05CH, AND REACHED
     A MAXIMUM OF   10000 CH.
DATA SET   2, ON STORAGE UNIT    1, AVERAGED    10234.93CH, AND REACHED
     A MAXIMUM OF   10240 CH.
```

KEY BLOCKS -

	BACKLOG			AVERAGE DELAY (MS)		TIME
BLOCK	MAXIMUM	AVERAGE	CURRENT	ALL	DELAYED	2.02SEC
1138	0	0	0	0	0	
1151	20	0.13	0	4	4	
1182	1	0	0	0	0	
1184	1	0.06	1	1.15	0	

1185	1	0	0	0	0
1192	1	0	0	0	0
1201	59	58.10	59	0	0
1204	0	0	0	0	0
1488	0	0	0	0	0
1495	0	0	0	0	0
1601	1	0	0	0	0
1605	35	0.04	22	0.40	0
1608	1	0	0	0	0
1675	1	0	0	0	0
1682	1	0	0	0	0
1686	1	0	0	0	0
1693	0	0	0	0	0
1706	0	0	0	0	0
1707	0	0	0	0	0
1708	1	0	0	0	0
1712	1	0	0	0	0
1734	0	0	0	0	0
1738	3	0.01	0	0 03	0
1748	1	0	0	0	0
1751	1	0	0	0	0
1753	1	0	0	0	0
1754	6	0.05	5	0.27	0
1808	0	0	0	0	0
1846	1	0	0	0	0
1847	1	0	0	0	0
1851	1	0	0	0	0
1935	0	0	0	0	0
1936	0	0	0	0	0
3004	0	0	0	0	0
3005	0	0	0	0	0
3032	33	1.27	28	20 97	20 97
3089	1	0	0	0	0
6002	0	0	0	0	0
8005	2	0.01	2	0.26	1 80
9052	1	0	0	0	0
11052	0	0	0	0	0

SUMMARY FOR TIME 2020 , RELATIVE TIME 2020
TALLY SUMMARIES
TABLE 1 --
AVERAGE = 732.73 STANDARD DEVIATION = 14.78

P (5)	SCORE	DELTA	CUM,SCORE	PERCENT	CUM,PERCENT
706 - 706	1	1	1	1.11	1.11
707 - 707	0	-1	1	0.00	1 11
708 - 708	0	0	1	0 00	1.11
709 - 709	1	1	2	1.11	2.22
710 - 710	1	0	3	1 11	3.33
711 - 711	0	-1	3	0 00	3.33

712 -	712	4	4	7	4 44	7.78
713 -	713	1	-3	8	1.11	8.89
714 -	714	1	0	9	1.11	10.00
715 -	715	1	0	10	1.11	11.11
716 -	716	4	3	14	4 44	15.56
717 -	717	2	-2	16	2.22	17.78
718 -	718	1	-1	17	1.11	18 89
719 -	719	0	-1	17	0.00	18.89
720 -	720	4	4	21	4.44	23.33
721 -	721	1	-3	22	1 11	24.44
722 -	722	0	-1	22	0.00	24.44
723 -	723	4	4	26	4.44	28.89
724 -	724	4	0	30	4.44	33.33
725 -	725	1	-3	31	1 11	34 44
726 -	726	4	3	35	4.44	38.89
727 -	727	4	0	39	4.44	43.33
728 -	728	4	0	43	4.44	47 78
729 -	729	0	-4	43	0.00	47 78
730 -	730	1	1	44	1.11	48.89
731 -	731	4	3	48	4.44	53.33
732 -	732	0	-4	48	0.00	53 33
733 -	733	4	4	52	4 44	57.78
734 -	734	4	0	56	4 44	62.22
735 -	735	0	-4	56	0 00	62 22
736 -	736	0	0	56	0.00	62 22
737 -	737	1	1	57	1.11	63 33
738 -	738	1	0	58	1.11	64.44
739 -	739	4	3	62	4.44	68.89
740 -	740	4	0	66	4.44	73.33
741 -	741	0	-4	66	0 00	73.33
742 -	742	4	4	70	4.44	77.78
743 -	743	0	-4	70	0.00	77 78
744 -	744	0	0	70	0 00	77.78
745 -	745	1	1	71	1 11	78.89
746 -	746	0	-1	71	0.00	78.89
747 -	747	4	4	75	4 44	83 33
748 -	748	0	-4	75	0.00	83.33
749 -	749	1	1	76	1.11	84 44
750 -	750	1	0	77	1 11	85.56
751 -	751	2	1	79	2.22	87.78
752 -	752	0	-2	79	0.00	87.78
753 -	753	0	0	79	0.00	87 78
754 -	754	0	0	79	0 00	87.78
755 -	755	0	0	79	0.00	87.78
756 -	756	1	1	80	1 11	88.89
757 -	757	0	-1	80	0.00	88.89
758 -	758	0	0	80	0.00	88.89
759 -	759	4	4	84	4.44	93.33
760 -	760	1	-3	85	1 11	94.44
761 -	761	3	2	88	3.33	97.78

762 -	762	0	-3	88	0.00	97.78
763 -	763	1	1	89	1 11	98.89
764 -	764	1	0	90	1.11	100.00

SUMMARY FOR TIME 2020 , RELATIVE TIME 2020

FACILITY	PERCENTAGE UTILIZATION	NUMBER OF TIMES USED	AVERAGE PERIOD PER USE	CURRENT PRIORITY	CURRENT RECOURSE	NUMBER SHELVED
1I	5.94	110	1 09	49	2000	
89U	0.00	88	0.00			
90U	0.00	82	0.00			
91U	0 00	88	0.00			
92U	0.00	20	0.00			
93U	0.00	140	0.00			
94U	0.00	140	0.00			
95U	0.00	140	0.00			
96U	0.00	78	0.00			
110U	0.00	12	0.00			
111U	0.00	12	0.00			
112U	0.00	12	0.00			
113U	0 00	12	0.00			
175U	1.19	7	3 43	52		
181U	1 39	8	3.50	52	9002	
182U	0.99	6	3 33	52	9002	
183U	0.59	4	3 00	52	9002	
184U	0.59	4	3.00	52	9002	
189U	0 00	114	0.00			
190U	0.00	111	0.00			
191U	0.00	114	0 00			
192U	0 00	49	0 00			
193U	0.15	25	0.12			
194U	0.15	6	0 50			
195U	0.15	3	1.00			
196U	0.05	1	1.00			
201U	0.00	21	0.00			
202U	0.00	3	0 00			
203U	1.19	4	6.00	52	9002	

SUMMARY FOR TIME 2020 , RELATIVE TIME 2020

STORAGE	CAPACITY	CONTENTS CURRENT	CONTENTS MAXIMUM	CONTENTS AVERAGE	NUMBER WITHDRAWN	AVERAGE PER ALL UNITS
1	10000	10000	10000	9995.05	0	1009.50
2	10240	10240	10240	10234.93	0	1009.50
111	125	3	3	3 00	0	1009.00
112	125	0	0	0.00	0	0.00
113	125	0	0	0.00	0	0.00
114	125	0	0	0 00	0	0.00
121	1	0	0	0 00	0	0.00
122	1	0	0	0.00	0	0.00

123	1	0	0	0.00	0	0.00
124	1	0	0	0.00	0	0.00
125	1	0	0	0.00	0	0 00
131	1400	300	360	3.12	28080	0.22
132	1400	60	60	0.71	360	3.00
133	1400	60	60	0.71	360	3.00
134	1400	120	120	0 71	360	2 40
141	60	0	60	0 09	540	0.33
142	60	0	60	0 09	540	0.33
143	60	0	60	0.09	540	0 33
144	60	0	60	0.00	240	0.00
145	60	0	60	0 00	240	0.00
151	17000000	20240	20240	20229.98	0	1009.50
152	17000000	0	0	0 00	0	0.00

CURRENT TRANSACTION COUNT	483
MAXIMUM NUMBER OF TRANSACTIONS	491
NUMBER OF TRY OPERATIONS	134841
NUMBER OF TRANSACTION MOVES	359972
NUMBER OF VARIABLE EVALUATIONS	1129007
MAXIMUM VARIABLE RECURSION	7
NUMBER OF ADMIT ATTEMPTS	1260456
NUMBER OF FUNCTION POINTS	1579
NUMBER OF BLOCK SPACES USED	1830
NUMBER OF REPORT LINES	97
NUMBER OF VARIABLE ELEMENTS	1314
CURRENT UTILIZATION OF STACKS	2573

DURING 0 55 SECONDS OF SIMULATED SHUTTLE OPERATIONS
A TOTAL OF 59 DIFFERENT FUNCTIONS WERE INTRODUCED.
THESE FUNCTIONS WERE ACTIVATED 275 TIMES, STATUS IS
260 WERE COMPLETED
44 ARE WAITING FOR NEXT ACTIVATION
13 ARE IN READY STATE, I.E. WAITING FOR CPU
0 ARE WAITING FOR MESSAGES TO COMPLETE
1 PRESENTLY EXECUTING, I.E. IN ACTIVE STATE
FUNCTIONS WERE INTERRUPTED 25 TIMES.
19 FUNCTION ACTIVATIONS WERE ABORTED AS FUNCTION STILL ACTIVE.

A TOTAL OF 0 MESSAGES WERE SUCCESSFULLY TRANSMITTED.
0 WERE IN BURST MODE OVER MULTIPLEXED DATA LINKS
0 TRANSMISSIONS WERE FOR LOADING OF MEMORIES
0 TRANSMISSIONS WERE INTERRUPTED BECAUSE OF BURST MODE OPERATIONS OR KILLING OF TASKS
0 SOURCE-DRIVEN MESSAGES WERE LOST DUE TO BACKLOGGING

PROCESSOR 1, V.M. 1, WAS USED 280 TIMES FOR
A TOTAL OF 550 MS UTILIZATION WAS 100 PERCENT.

DATA SET 1, ON STORAGE UNIT 1, AVERAGED 1072.57CH, AND REACHED
A MAXIMUM OF 10000 CH
DATA SET 2, ON STORAGE UNIT 1, AVERAGED 1312.57CH, AND REACHED
A MAXIMUM OF 10240 CH

KEY BLOCKS -

	BACKLOG			AVERAGE DELAY (MS)		TIME
BLOCK	MAXIMUM	AVERAGE	CURRENT	ALL	DELAYED	240.55SEC.
1138	0	0	0	0	0	
1151	20	0	0	4	4	
1182	1	0	0	0	0	
1184	1	0	1	2 51	0	
1185	1	0	0	0	0	
1192	1	0	0	0	0	
1201	59	58.99	59	0	0	
1204	0	0	0	0	0	
1488	0	0	0	0	0	
1495	0	0	0	0	0	
1601	0	0	0	0	0	
1605	0	0	0	0	0	
1608	0	0	0	0	0	
1675	0	0	0	0	0	
1682	0	0	0	0	0	
1686	0	0	0	0	0	
1693	0	0	0	0	0	

1706	0	0	0	0	0
1707	0	0	0	0	0
1708	0	0	0	0	0
1712	0	0	0	0	0
1734	0	0	0	0	0
1738	0	0	0	0	0
1748	0	0	0	0	0
1751	0	0	0	0	0
1753	0	0	0	0	0
1754	0	0	0	0	0
1808	0	0	0	0	0
1846	0	0	0	0	0
1847	0	0	0	0	0
1851	0	0	0	0	0
1935	0	0	0	0	0
1936	0	0	0	0	0
3004	0	0	0	0	0
3005	0	0	0	0	0
3032	41	0.05	13	17 99	17.99
3089	1	0	0	0	0
6002	0	0	0	0	0
8005	0	0	0	0	0
9052	0	0	0	0	0
11052	0	0	0	0	0

SUMMARY FOR IIML 240550 , RELATIVE TIME 240550
TALLY SUMMARIES
TABLE 1 --
AVERAGE = 734 96 STANDARD DEVIATION = 13.36

P (5)	SCORE	DELTA	CUM,SCORE	PERCENT	CUM,PERCENT
706 - 706	0	0	0	0 00	0 00
707 - 707	0	0	0	0.00	0.00
708 - 708	1	1	1	0 36	0 36
709 - 709	1	0	2	0.36	0.73
710 - 710	1	0	3	0 36	1.09
711 - 711	0	-1	3	0 00	1 09
712 - 712	13	13	16	4 73	5.82
713 - 713	4	-9	20	1 45	7 27
714 - 714	0	-4	20	0.00	7 27
715 - 715	1	1	21	0 36	7.64
716 - 716	1	0	22	0 36	8.00
717 - 717	7	6	29	2.55	10 55
718 - 718	1	-6	30	0 36	10.91
719 - 719	14	13	44	5.09	16 00
720 - 720	1	-13	45	0 36	16 36
721 - 721	1	0	46	0.36	16 73
722 - 722	1	0	47	0.36	17.09
723 - 723	14	13	61	5 09	22.18
724 - 724	14	0	75	5 09	27 27

725 -	725	1	-13	76	0.36	27.64
726 -	726	14	13	90	5 09	32 73
727 -	727	1	-13	91	0 36	33 09
728 -	728	1	0	92	0 36	33.45
729 -	729	2	1	94	0 73	34.18
730 -	730	4	2	98	1 45	35.64
731 -	731	14	10	112	5 09	40 73
732 -	732	7	-7	119	2 55	43.27
733 -	733	14	7	133	5 09	48.36
734 -	734	1	-13	134	0.36	48 73
735 -	735	14	13	148	5.09	53.82
736 -	736	14	0	162	5 09	58.91
737 -	737	1	-13	163	0 36	59.27
738 -	738	1	0	164	0 36	59 64
739 -	739	13	12	177	4 73	64.36
740 -	740	1	-12	178	0 36	64 73
741 -	741	7	6	185	2.55	67 27
742 -	742	14	7	199	5 09	72.36
743 -	743	0	-14	199	0 00	72 36
744 -	744	13	13	212	4.73	77.09
745 -	745	0	-13	212	0 00	77 09
746 -	746	4	4	216	1 45	78.55
747 -	747	13	9	229	4.73	83.27
748 -	748	1	-12	230	0 36	83.64
749 -	749	1	0	231	0.36	84 00
750 -	750	1	0	232	0.36	84.36
751 -	751	1	0	233	0 36	84.73
752 -	752	0	-1	233	0 00	84 73
753'-	753	7	7	240	2.55	87 27
754 -	754	2	-5	242	0.73	88.00
755 -	755	0	-2	242	0 00	88.00
756 -	756	14	14	256	5.09	93.09
757 -	757	1	-13	257	0.36	93 45
758 -	758	1	0	258	0.36	93.82
759 -	759	14	13	272	5.09	98 91
760 -	760	1	-13	273	0 36	99 27
761 -	761	0	-1	273	0 00	99 27
762 -	762	0	0	273	0.00	99.27
763 -	763	1	1	274	0.36	99.64
764 -	764	1	0	275	0.36	100 00

SUMMARY FOR TIME 240550 , RELATIVE TIME 240550

FACILITY	PERCENTAGE UTILIZATION	NUMBER OF TIMES USED	AVERAGE PERIOD PER USE	CURRENT PRIORITY	CURRENT RECOURSE	NUMBER SHELVED
11	0 23 .	280	1 96	14	2000	

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

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SUMMARY FOR TIME 240550 , RELATIVE TIME 240550

STORAGE	CAPACITY	CONTENTS CURRENT	CONTENTS MAXIMUM	CONTENTS AVERAGE	NUMBER WITHDRAWN	AVERAGE PERIOD ALL UNITS
1	10000	10000	10000	1072 57	0	12900.32
2	10240	10240	10240	1312.57	0	15416.90
111	125	3	3	3 00	0	120274 00
112	125	0	0	0 00	0	0.00
113	125	0	0	0 00	0	0 00
114	125	0	0	0.00	0	0 00
121	1	0	0	0.00	0	0.00
122	1	0	0	0.00	0	0.00
123	1	0	0	0.00	0	0 00
124	1	0	0	0 00	0	0 00
125	1	0	0	0.00	0	0.00
131	1400	0	0	0.00	0	0.00
132	1400	0	0	0 00	0	0 00
133	1400	0	0	0.00	0	0 00
134	1400	0	0	0 00	0	0 00
141	60	0	0	0.00	0	0.00
142	60	0	0	0.00	0	0 00
143	60	0	0	0.00	0	0 00
144	60	0	0	0.00	0	0 00
145	60	0	0	0.00	0	0 00
151	17000000	20240	20240	2385 14	0	14173 52
152	17000000	0	0	0 00	0	0 00

CURRENT TRANSACTION COUNT	296
MAXIMUM NUMBER OF TRANSACTIONS	306
NUMBER OF TRY OPERATIONS	97043
NUMBER OF TRANSACTION MOVES	220824
NUMBER OF VARIABLE EVALUATIONS	519916
MAXIMUM VARIABLE RECURSION	7
NUMBER OF ADMIT ATTEMPTS	593458
NUMBER OF FUNCTION POINTS	1579
NUMBER OF BLOCK SPACES USED	1830
NUMBER OF REPORT LINES	97
NUMBER OF VARIABLE ELEMENTS	1314
CURRENT UTILIZATION OF STACKS	1696

APPENDIX E

TERMS AND ABBREVIATIONS

A	AA	- Accelerometer Assembly
	ABSOL	- Absolute
	ACCEL	- Accelerometer
	ACQ	- Acquisition
	ACT	- Actuator
	A/D	- Analog-to-Digital
	ALT	- Approach and Landing Test
	AOA	- Abort-Once-Around
	AS	- Ascent
	ASA	- Aerosurface Actuator
	ASC	- Ascent
	ATVC	- Ascent Thrust Vector Controller
	AUTO	- Automatic
	AVAIL	- Available
	AVG	- Average
B	BF	- Body Flap
	BITE	- Built-In Test Equipment
	BK	- Brake
	bps	- bits per second
C	CALC	- Calculation
	CAS	- Command Augmentation System
	CFN	- Continuous Function (MODLIT)
	CH/MS	- Characters per Millisecond (appendix C)
	CHNL	- Channel
	CMD	- Command
	CMDS	- Commands
	CMPTR	- Computer
	COMP	- Computation
	COMP	- Component
	COMPL	- Complete
	CPDS	- Computer Program Development Specification
	CPU	- Central Processing Unit
	CRT	- Cathode Ray Tube
	CTR	- Counter
D.	DAP	- Digital Autopilot
	DD	- Dedicated Display
	DDPC	- Digital Data Processing Computer
	DDPS	- Digital Data Processing System
	DDU	- Display Driver Unit
	DED	- Dedicated
	DEF	- Deflection
	DEFL	- Deflection
	DEU	- Display Electronic Unit
	DFN	- Discrete Function (MODLIT)
	DISP	- Display
	DMA	- Direct Memory Access
	DPS	- Data Processing System
	DRL	- Data Requirements List
	DU	- Display Unit
E	EIU	- Engine Interface Unit
	ELEV	- Elevon
	ENG.	- Engine
	EQ	- Equal To
	ET	- External Tank
	EV	- Event
	EVT	- Event
	EXEC	- Executive, Execute
	EXTRAP	- Extrapolation
F	FA	- Flight Aft MDM
	FC	- Flight Control
	FC	- Flight Critical
	FC	- Fast Cycle
	FCN	- Function
	FCOS	- Flight Computer Operating System
	FCS	- Flight Control System
	FDBCK	- Feedback
	FDI	- Fault Detection and Identification
	FDIR	- Fault Detection, Identification, and Recovery
	FF	- Flight Forward MDM
	FSSR	- Functional Subsystem Software Requirement
	FWD	- Forward

G
- GN&C - Guidance, Navigation, and Control
- GPC - General-Purpose Computer
- GR - Greater Than
- GR/EQ - Greater Than or Equal To
- GUID - Guidance

H
- HYD - Hydraulic

I
- IBM - International Business Machines Corporation
- ICC - Intercomputer Communication
- IGN - Ignition
- IMSIM - Information Management System Interpretive Model
- IMU - Intertial Measurement Unit
- INH - Inhibit
- INIT - Initial, Initiation
- INS - Insertion
- INTERV - Interval
- I/O - Input/Output
- IOP - Input-Output Processor
- IPL - Initial Program Load

J
- JSC - Johnson Space Center

K
- KB - Keyboard
- Kbps - Kilobits per second
- KBU - Keyboard Unit
- KEYBD - Keyboard

L
- LA - Launch Aft MDM
- LA - Left Aft
- LCA - Load Control Assembly
- LCH - Launch
- LDB - Launch Data Bus
- LF - Launch Forward MDM
- LF - Left Forward
- LH - Left-Hand
- LH2 - Liquid Hydrogen
- LIB.DS - Library Data Set
- LL - Launch Left MDM
- LOX - Liquid Oxygen
- LPS - Launch Processing System
- LR - Launch Right MDM
- LVON - Elevon

M
- MAX - Maximum
- MCA - Motor Control Assembly
- MCDS - Multifunction CRT Display System
- MCIU - Manipulator Control Interface Unit
- MDM - Multiplexer/Demultiplexer
- ME - Main Engine
- M E - Message End (appendix C)
- MEC - Master Events Controller
- MECO - Main Engine Cutoff
- MEM - Memory
- MET - Mission Elapsed Time
- Mhz - Megahertz
- MIA - Multiplexer Interface Adapter
- MM - Major Mode
- MM - Mass Memory
- MMU - Mass Memory Unit
- MODLIT - SDC Discrete System Simulator
- MPS - Main Propulsion System
- ms - millisecond
- MS - Message Start (appendix C)
- MSBLS - Microwave Scan Beam Landing System
- msg - message
- MTU - Master Timing Unit

N
- NA - Not Applicable
- NASA - National Aeronautics and Space Administration
- NAV - Navigation
- NEG - Negative
- NW - Nosewheel
- ns - nanosecond

O
- OA - Operational Instrumentation MDM-Aft
- OF - Operational Instrumentation MDM-Forward
- OI - Orbital Flight Test
- OMS - Orbital Maneuvering System
- OPS - Orbiter Project Schedule
- ORB - Orbiter
- ORG - Organization of Dataset

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P
- PARAM - Parameter
- PCMMU - Pulse Code Modulator Master Unit
- PDI - Payload Data Interleaver
- PIC - Pyrotechnic Initiator Controller
- PF - Payload Operational Instrumentation MDM-Forward
- PL - Payload
- PM - Performance Monitoring
- POS - Positive, Position
- POS/NEG- Positive/Negative
- PRO - Proceed
- PROC - Processing
- PROCSR - Processor
- PROP - Propulsion
- PWR - Power

R
- RALT - Radar Altimeter
- RCS - Reaction Control System
- RECON - Reconfiguration
- REL - Relative
- RELATV - Relative
- RF1 - Random Function (MODLIT)
- RG - Rate Gyro
- RGA - Rate Gyro Assembly
- RH - Right-Hand
- RHC - Rotational Hand Controller
- RM - Redundancy Management
- RNG - Range
- ROTAT - Rotation
- RTLS - Return to Launch Site
- R/S - Redundant Set

S
- SB - Speedbrake
- S D - Standard Deviation
- SDC - System Development Corporation
- SEL - Select
- SEP - Separation
- SEQ - Sequencer
- SIG - Signal
- SIM - Simulation
- SM - System Management
- SOP - Subsystem Operating Program
- S O.W - Statement of Work
- Spec - Specialist
- SRB - Solid Rocket Booster
- SS - Space Shuttle
- SSIP - System Software Interface Processor
- SSME - Space Shuttle Main Engine
- ST1G - Stage 1 Guidance
- ST2G - Stage 2 Guidance
- STR - Stroke
- STRT - Start
- SW - Switch
- SYS - System
- S1G - Stage 1 Guidance
- S2G - Stage 2 Guidance

T.
- TACAN - Tactical Air Navigation
- TAEM - Terminal Area Energy Management
- TBD - To be Determinded
- T E - Task Ends (appendix C)
- TG - Go for Task (appendix C)
- THC - Translational Hand Controller
- THROT - Throttle
- TI - Task Interrupt (appendix C)
- TOT - Total
- TRANSM - Transmission
- TRX - Transmission
- TS - Task Start (appendix C)
- TUS - Time Units (appendix C)
- TVC - Thrust Vector Control
- T W - Task in Wait State (appendix C)
- T X - Task in Execution (appendix C)

U.
- UI - User Interface
- UPP - User Parameter Processing

V.
- V - Variable
- VERIF - Verification
- VIRT MACH - Virtual Machine
- VLV - Valve
- V M. - Virtual Memory
- VM - Virtual Machine
- VU - Vehicle Utilities

W.
- WD - Word

X.
- X - Savex cell (MODLIT)
- XDCR - Transducer

APPENDIX F

REFERENCES

1 System Development Corporation, TM-5257/105/00A
Reference Manual for the MODLIT Discrete System Simulator
21 August 1974

2 System Development Corporation, TM-5328/102/00
IMSIM Information Management System Simulator - Users Manual
21 August 1974

3 System Development Corporation, TM-5328/302/00
IMSIM Program Logic Manual
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